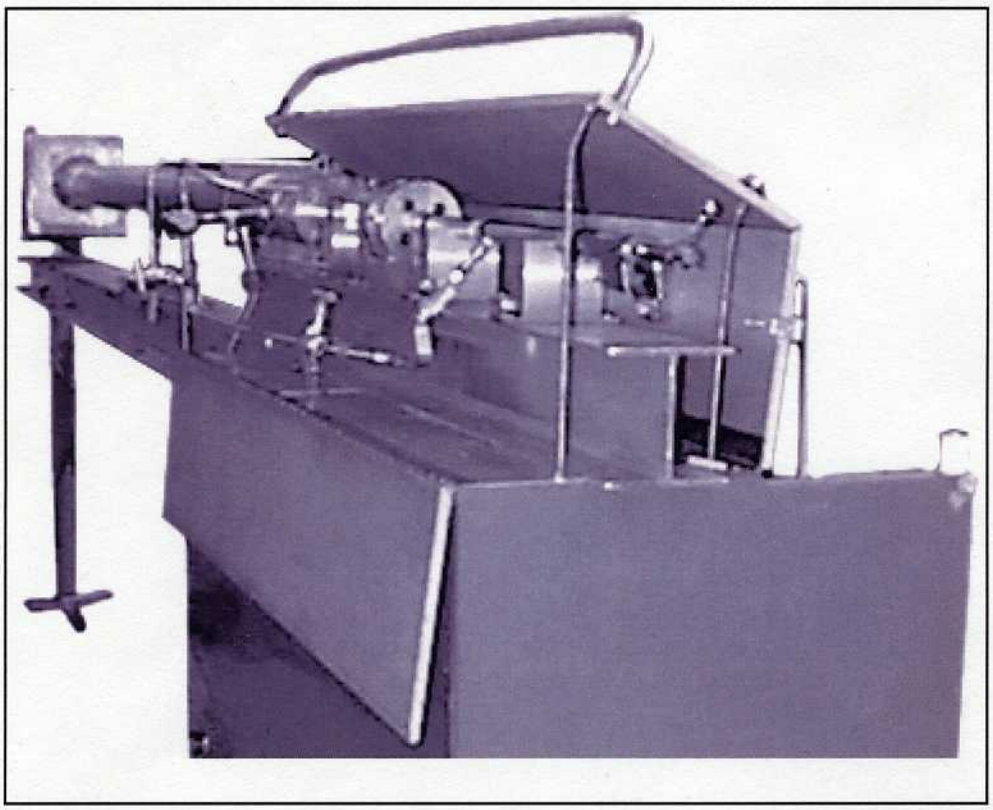
Micro Light Gas Gun



Environmental Effect Branch, Materials and Processes Laboratory
Building 4612

National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, AL 35812

Release Authority	Name	Title	Organization	Date
Office of Primary Responsibility	H DeWitt Burns for	Environmental Effects Branch Chief	EM50	2/14/2005
	Alvy Erdahl	Industrial Safety	QD50	2/14/05

Revision	Date	Originator	Description	Affected Pages
Baseline	2/15/05	Mary Hovater	Document converted from ED31-OWI-029. Previous history retained in system as part of canceled or superseded ISO Document files.	

This document baselines the Organizational Work Instruction (OWI) for the Micro Light Gas Gun in Building 4612 of Marshall Space Flight Center. Any change to this OWI shall be submitted to and approved by the Environmental Effects Branch Chief, EM50. Revisions may be also be submitted to the concurring organizations listed below for review and concurrence by memo. The original OWI and all changes shall be maintained by EM50.

Concurring organizations:
SEEF Test Operations Contractor
EM50 Space & Environmental Effects Team Lead
Industrial Safety, QS50
Environmental Health, AD02M

Contents

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1.0 Scope

1.1 Scope

The scope of this Organizational Work Instruction (OWI) is the operation of the Micro Light Gas Gun (MLGG) located in the Impact Testing Facility in Building 4612 at Marshall Space Flight Center (MSFC).

1.2 Purpose

Meteoroids and orbital debris pose a serious damage and decompression threat to space vehicles. Any spacecraft can suffer catastrophic damage or decompression if it receives a hypervelocity impact from an object larger than a few grams. Collisions with smaller objects cause serious surface erosion with subsequent effects on the surface thermal, electrical, and optical properties. If a system cannot be shielded, operational constraints or procedures may be imposed to reduce the threat of critical damage to the spacecraft.

The purpose of the MLGG is to test material configurations in the laboratory-created micrometeoroid and space debris environment. This testing is done in support of materials and processes investigations conducted by the NASA/MSFC Environmental Effects Branch.

1.3 Applicability

This instruction applies to the Environmental Effects Branch of the Materials and Processes Laboratory at MSFC.

2.0 Applicable Documents

29CFR 1910.103, Occupational Safety and Health Standard: *Hydrogen.*

CGA G-5.4-2001, *Standard for Hydrogen Piping Systems at Consumer Locations.*.

MPR 1040.3. *MSFC Emergency Plan.*

MPR 1840.2. *MSFC Hazard Communications Program*.

MPR 8715.1. *MSFC Safety, Health, and Environmental (SHE) Program.*

MWI 3410.1. *Personnel Certification Program.*

MWI 8621.1. *Close Call and Mishap Reporting and Investigation Program.*

MWI 8715.10. *Explosives, Propellant, and Pyrotechnics Program.*

MWI 8715.15. *Ground Operations Safety Assessment and Risk Mitigation Program*

NASA NSS 1740.12. Safety *Standards for Explosives, Propellants, and Pyrotechnics.*

Note: Personnel **shall always refer** to the current version of applicable documents.

3.0 Definitions

3.1 Definitions

Hot Charge. A powder and primer charge in the MLGG cartridge.

MLGG Room (Gun Room). Room 1000 of Building 4612.

NASA. Marshall Space Flight Center EM50 responsible personnel.

Prepared Charge. A weighted amount of powder without the cartridge.

Range. Room 1000 of Building 4612.

Range Engineer. The person responsible for overall operations of the range, specific planning of test programs, and implementation of safety programs.

Range Operator. The person who operates control equipment during the firing sequence under the guidance of the Range Engineer.

Range Assistant. The person who assists the Range Engineer or Range Operator in various tasks in the Gun Room.

Range Lead. The person responsible for the overall Micrometeoroid and Space Debris Simulation Program in the MSFC Impact Facility.

3.2 Acronyms

AR	Accelerated Reservoir
COTR	Contracting Officer's Technical Representative
LGG	Large Gas Gun
MLGG	Micro Light Gas Gun
MPG	Marshall Procedures and Guidelines
MSFC	Marshall Space Flight Center
MWI	Marshall Work Instruction
NASA	National Aeronautics and Space Administration
OWI	Organizational Work Instruction
PA	Public Address (system)
PPE	Personal Protective Equipment
S&MA	Safety and Mission Assurance (office)
SHE	Safety, Health, and Environmental (program)

4.0 Instructions

The purpose of testing with the Micro Light Gas Gun is to investigate the orbital debris environment. For a physical description of the MLGG, see section 9.1.

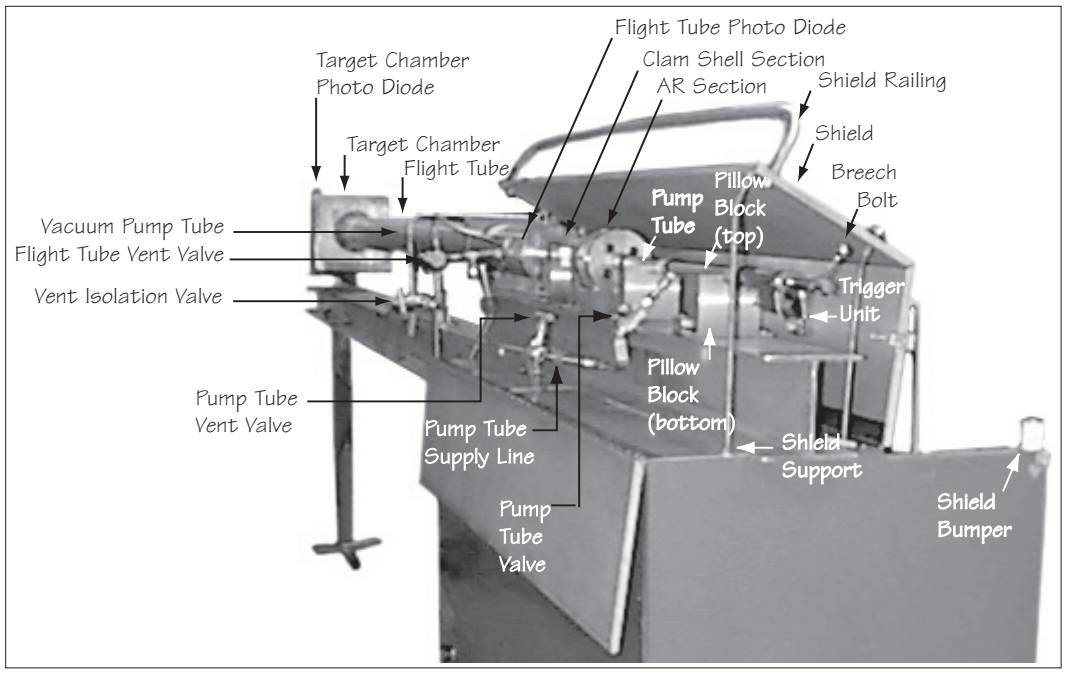
All operations of this equipment shall be conducted using the applicable documents referenced above (section 2). All critical measuring devices shall be in current calibration (section 9.4). All data and test results shall be recorded on data sheets (section 7.2), which are compiled in notebooks maintained by the Range Lead. A summary of pertinent test information and test results shall be compiled in a database maintained by the Range Lead.

4.1 System Initial Preparation

Personnel shall **perform** the following steps to prepare the MLGG for use, referring to Figure 4.1-1 as needed. Table 7.2-1 presents these steps in a checklist form. **Post** this form in both the control room and the gun room, and **mark** each step as it is completed. Archiving of the completed checklist for each shot is not required.

4.1.1. **Ensure** that all valves on the control panel are closed.

Figure 4.1-1.
Micro Light Gas Gun



4.1.2. **Prepare** the target chamber.

4.1.2.1. **Prepare** the target assembly (Figure 4.1-2).

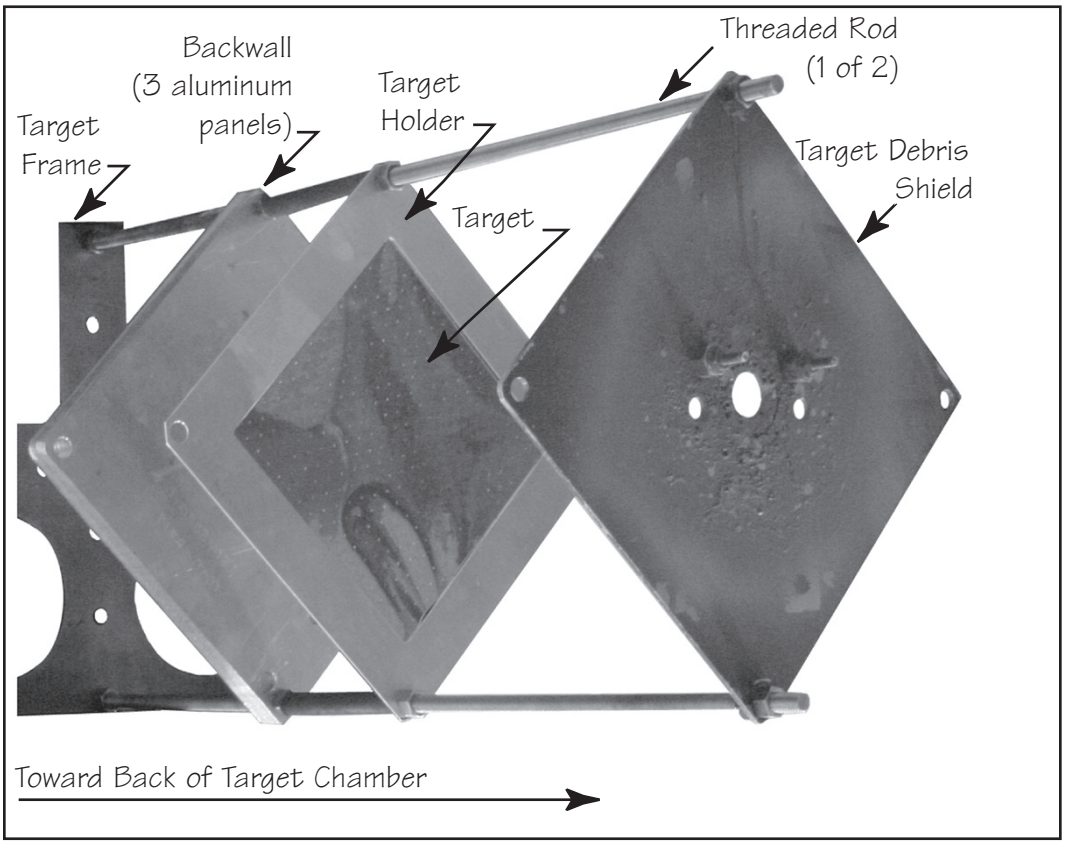


Figure 4.1-2.
Target Assembly

4.1.2.1.1. **Slide** three aluminum panels, which act as a backwall, onto the threaded rods of the target holder. **Position** the backwall forward of the target frame, and **secure** the panels to both rods with nuts on both sides of the backwall. **Secure** the nuts finger tight.

4.1.2.1.2. **Position** the target in the assembly in accordance with the MLGG Work Request (Figure 7.2-6).

4.1.2.1.2.1. **Attach** the target material to the target holder.

4.1.2.1.2.2. **Slide** the target in its frame onto the two threaded rods of the target holder to the position indicated for the test. **Attach** the target frame to the threaded rods with nuts, and **secure** the nuts finger tight.

4.1.2.1.3. **Slide** the target debris shield onto the two threaded rods of the target holder. **Attach** the shield to the rods with nuts, and **secure** the nuts finger tight.

4.1.2.3. **Slide** the target assembly into the target chamber (Figure 4.1-3).

4.1.2.4. **Position** the plexiglass target chamber shield, and **secure** it using C clamps (Figure 4.1-4).

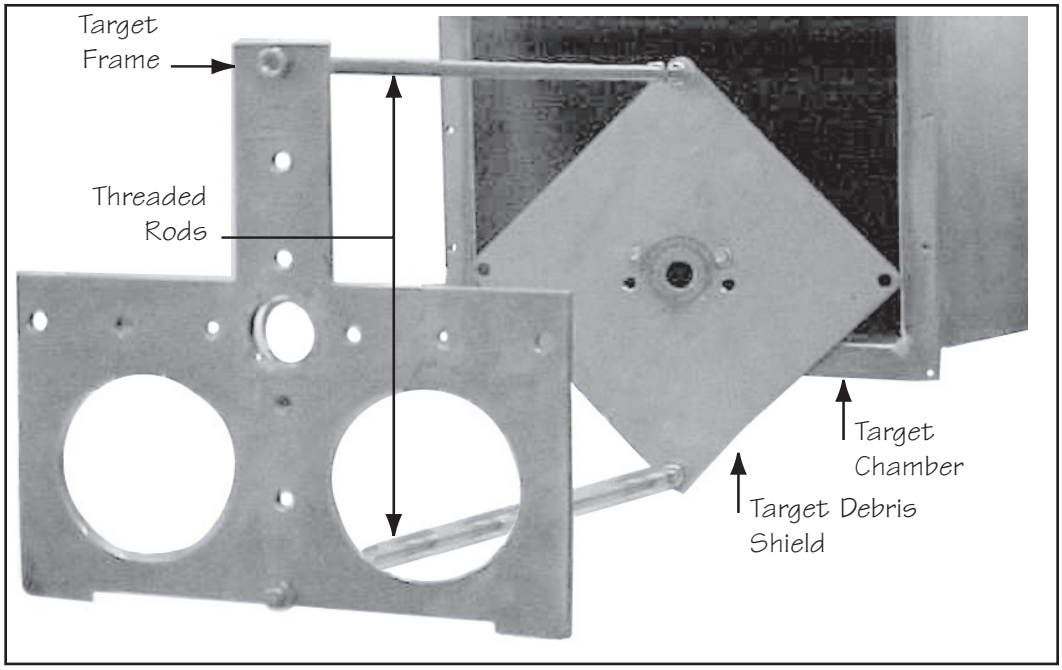


Figure 4.1-3. Target Assembly (without backwall and target) oriented for insertion into Target Chamber

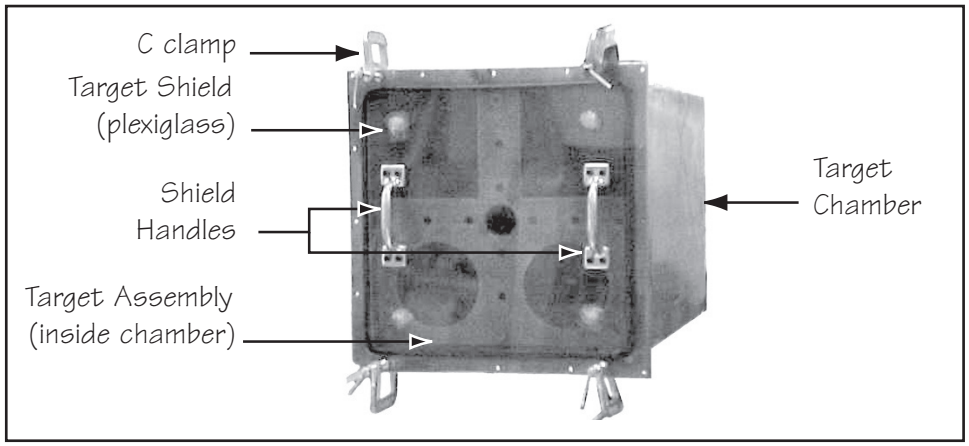


Figure 4.1-4. Assembled Target Chamber

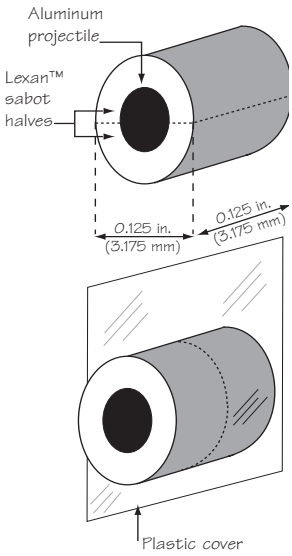


Figure 4.1-5. Sabot with Projectile

4.1.3. **Prepare** the clam shell assembly.

4.1.3.1. **Clean** the barrel by wiping it with an alcohol-soaked cloth until it is visibly clean.

4.1.3.2. The MLGG will fire either a projectile or a slug. **Load** a projectile and sabot (or a slug) in the barrel. Figure 4.1-5 illustrates the sabot/projectile assembly provided by the manufacturer.

4.1.3.2.1. To load a projectile, **place** one end of the barrel over the sabot, and **push** it firmly. **Ensure** that the sabot is flush with the barrel.

Note: The plastic cover will drop away.

4.1.3.2.2. To load a slug (same size as the sabot), **perform** the following steps:

4.1.3.2.2.1. **Wrap** the MLGG barrel with rubber, and **place** the barrel upright in a vise.

4.1.3.2.2.2. **Place** a slug into the end of the barrel. **Push** the slug firmly into the barrel with a plastic pusher.

4.1.3.2.2.3. **Remove** the barrel from the vise, and **remove** the rubber wrapping.

4.1.3.3. **Place** the cleaned and loaded barrel into the bottom half of the clam shell (Figure 4.1-6), with the end of the barrel containing the projectile toward end of the clam shell that will attach to the AR section, *i.e.,* the shorter threaded end.

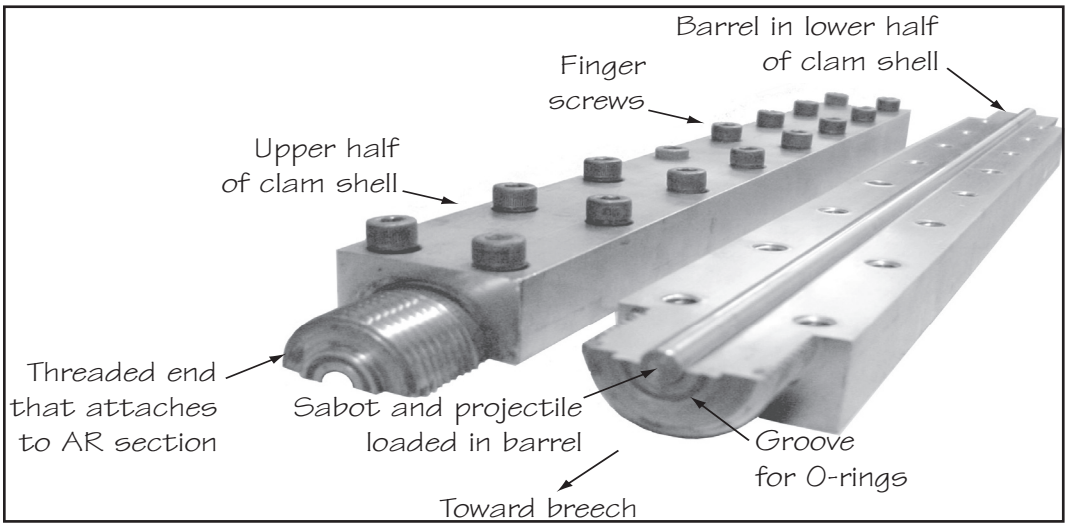


Figure 4.1-6.
Clam Shell with Barrel

4.1.3.4. **Place** two half strips of clear tape [each approximately 3 in. (7.5 cm) long] lengthwise along the top of the barrel to prevent slippage.

4.1.3.5. **Place** the top half of the clam shell over the bottom half. **Tighten** the clam shell assembly screws securely using a 5/32-in. Allen wrench. With a torque wrench, **torque** the screws to 15 ft-lb.

4.1.3.6. **Position** this assembly in the pillow blocks closest to the flight tube.

4.1.3.7. **Place** two O-rings in the O-ring grooves on the flight tube end of the clam shell (Figure 4.1-7).

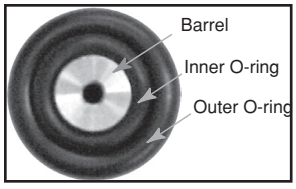


Figure 4.1-7.
O-rings positioned on end of barrel

4.1.3.8. **Thread** the muzzle adapter onto the flight tube end of the clam shell assembly (Figure 4.1-8).

4.1.3.9. **Thread** the muzzle adapter (with clam shell assembly attached) onto the flight tube handtight (Figure 4.1-9).

Figure 4.1-8.
Muzzle Adapter attached to Clam Shell Assembly

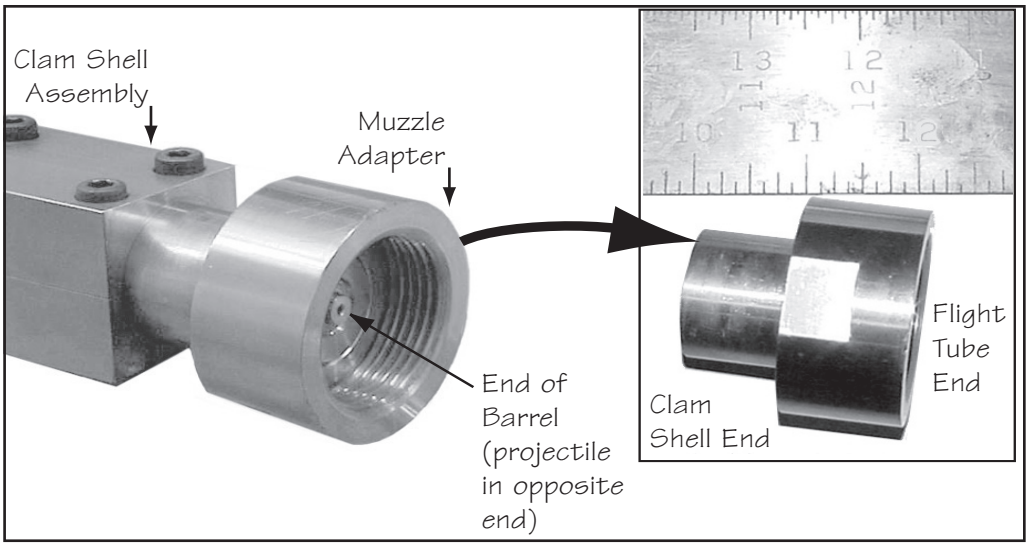
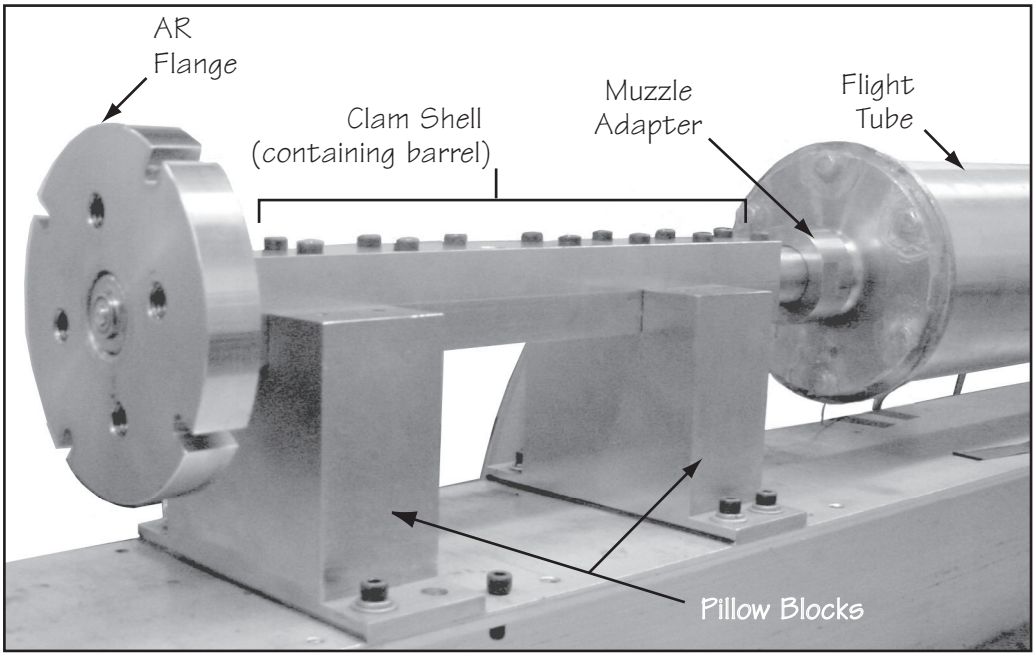


Figure 4.1-9
Flight Tube Attached to Clam Shell Assembly



4.1.3.10. Thread the Accelerated Reservoir (AR) flange marked "Clam Assembly" onto the AR end of the clam shell assembly. Figure 4.1-9 shows the MLGG assembled through step 4.1.4.10.

4.1.4. **Prepare** the pump tube/AR section.

4.1.4.1. **Place** a burst disk into the AR section (Figure 4.1-10).

4.1.4.2. **Position** the pump tube into the pillow blocks.

4.1.4.3. **Place** the AR flange marked "Pump Tube" onto the pump tube.

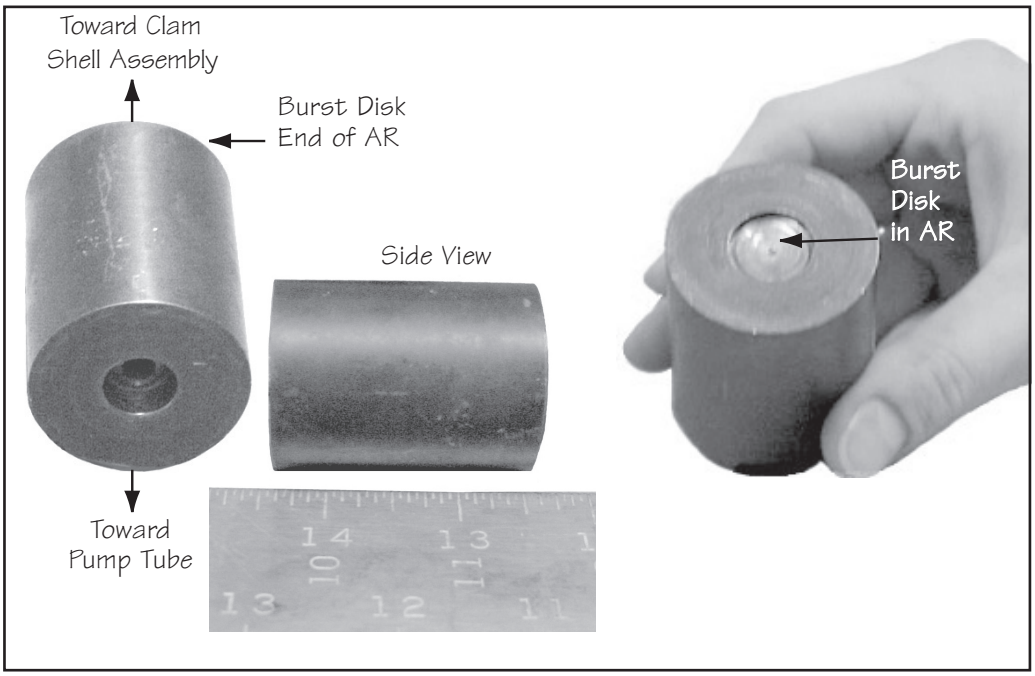


Figure 4.1-10.
AR Section and Burst Disk

4.1.4.4. **Position** the AR section between the flange attached to the clam shell assembly and the flange attached to the pump tube. **Ensure** that the end of the AR section containing the burst disk faces toward the flange on the clam shell assembly.

4.1.4.5. **Slide** the pump tube into place, inserting its flange into the AR section.

4.1.4.6. **Insert** four 3/8-in. bolts through the pump tube AR flange and into the clam shell AR flange. **Attach** these bolts finger tight.

4.1.4.7. **Attach** the pump tube supply line to the pump tube valve (Figure 4.1-1).

4.1.4.8. Using a 7/16-in. Allen wrench, **tighten** the 3/8-in. AR bolts securely (Figure 4.1-11). **Use** a torque wrench to apply 50 ft-lb torque to the bolts.

Note: This action seals the AR section and aligns the pump tube, AR section, and clam shell assembly in the firing position.

4.1.4.9. **Secure** the tops of the pillow blocks onto the clam shell and pump tube pillow blocks, starting at the flight tube and working toward the breech.

Note: **Orient** each pillow block top so that the arrow points toward the target chamber.

4.1.4.10. **Position** the piston (Figure 4.1-12) into the pump tube through the breech. **Firmly tap** the piston into place with the rounded end of the pis-

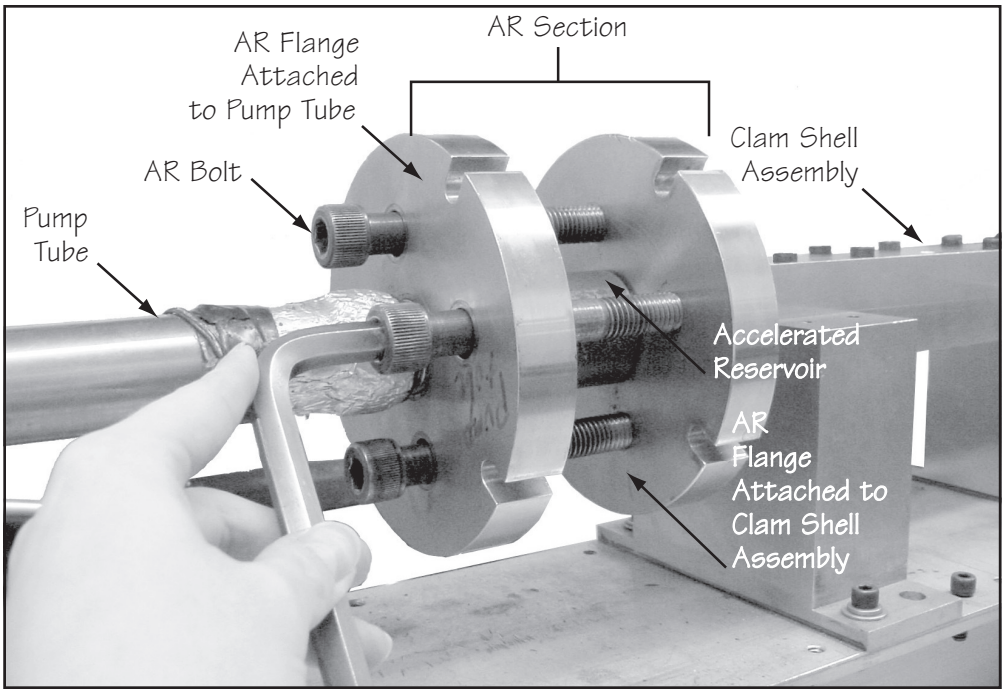


Figure 4.1-11.
Aligning the Pump Tube, AR Section, and Clam Shell Assembly in the firing position

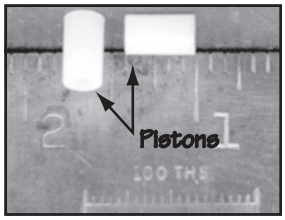


Figure 4.1-12.
MLGG Pistons

ton pushing rod until the front of the tape on the pushing rod reaches the breech.

4.1.5. **Insert** the breech bolt (Figure 4.1-1).

4.1.6. **Lift** the steel control shield onto the shield supports.

4.1.7. **Ensure** that all valves on the gun system are closed.

4.1.8. **Verify** that the hydrogen monitor, located on the east range wall (Figure 4.1-13) is calibrated in accordance with the manufacturer's specifications and that the monitor is working.

4.1.9. On the east range wall, **ensure** that both the **GN_2 Supply Valve** and **GH_2 Supply Valve** are closed (Figure 4.1-14).

4.1.10. Outside the east door of the range on the GN_2 cart (Figure 4.1-15), **ensure** that the GN_2 cylinder registers at least 100 psi.

Note: *If the GN_2 supply is not at least 100 psi,* **call** MSFC's propellants and pressurized systems service contractor to refill the cylinder. **Do not proceed** with MLGG system preparation until the supply has been replenished.

4.1.11. **Open** the **GN_2 Supply Valves** on the cart and the outside wall beside the cart (Figures 4.1-15, -16, and -17).

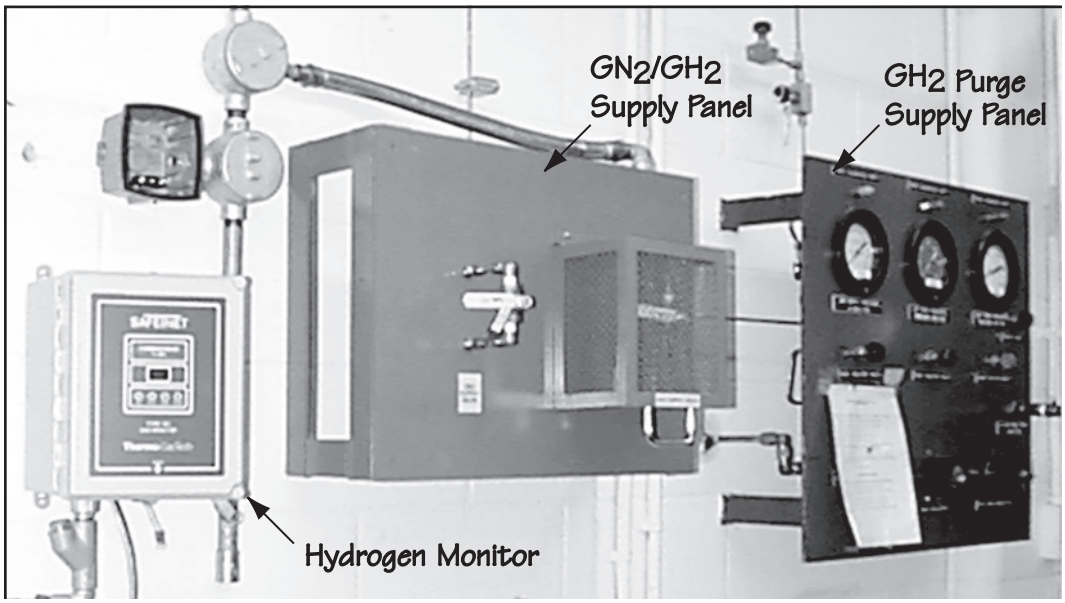


Figure 4.1-13.
Panels on east range wall

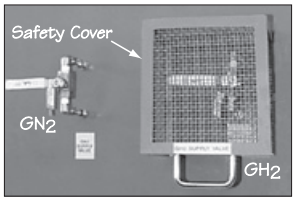


Figure 4.1-14.
GN_2 and GH_2 Supply Valves in closed positions

4.1.12. **Check** that the GN_2 pressure is set at 25 psig on the **GN_2 Purge Supply Panel,** located on the east range wall (Figures 4.1-13 and 4.1-18).

4.1.13. At the K-bottle station outside Building 4612 (Figure 4.1-19), **verify** that the **GH_2 Bleed Valve** is **closed**.

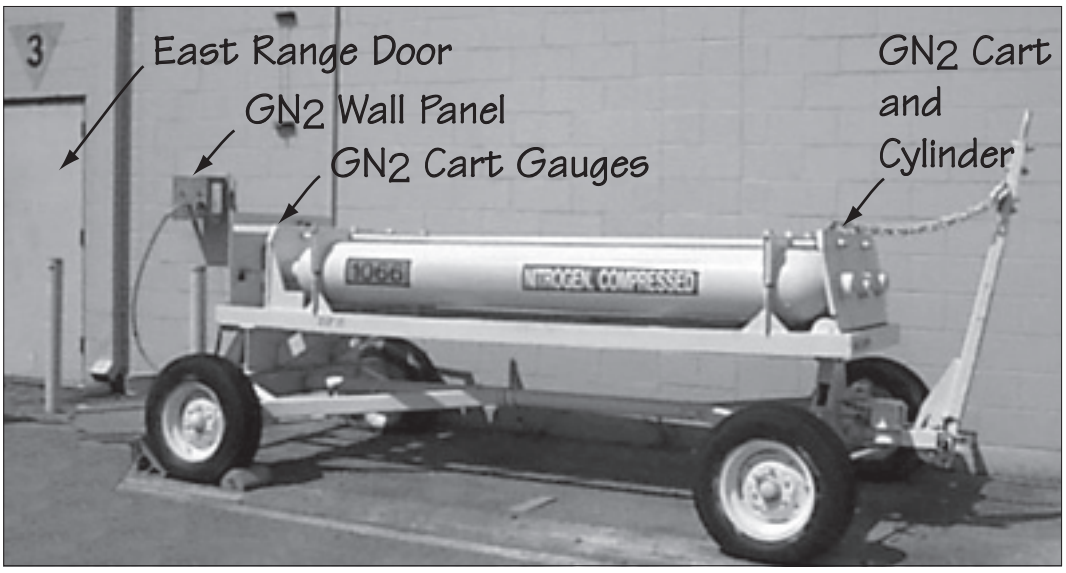


Figure 4.1-15.
GN_2 Supply Cart and outside wall panel

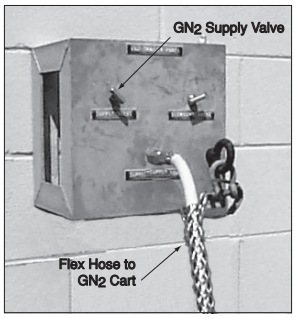


Figure 4.1-16.
Outside GN_2 Supply Valve

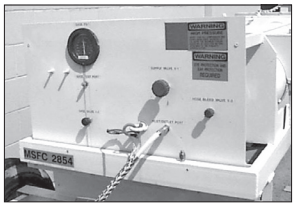


Figure 4.1-17
GN_2 Cart Gauge Panel

4.1.14. **Open** the hydrogen K-bottle.

4.1.15. **Ensure** that the hydrogen K-bottle gauge (Figure 4.1-19) registers a minimum of 200 psi. *If the gauge **does** register a minimum of 200 psi,* **proceed** with step 4.1.16. *If the gauge **does not** register a minimum of 200 psi,* **install** a fresh hydrogen K-bottle, **leak check** the bottle, and **resume** procedure at step 4.1.13.

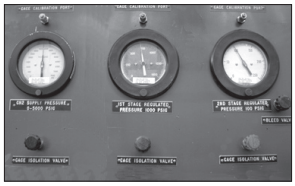


Figure 4.1-18.
GN_2 Purge Supply Panel

4.1.16. **Set** the hydrogen K-bottle regulator to the desired pressure. **Ensure** that the regulator reads no more that 130 psi (Figure 4.1-19).

4.1.17. **Purge** the GH_2 lines by performing the following steps:

4.1.17.1. On the back of the gun, **ensure** that the **Flight Tube Vent Valve** (Figure 4.1-20) and the **Pump Tube Valve** (Figure 4.1-21) are closed.

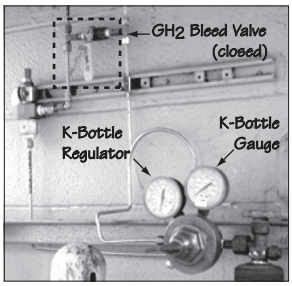


Figure 4.1-19.
Bottle station outside Building 4612

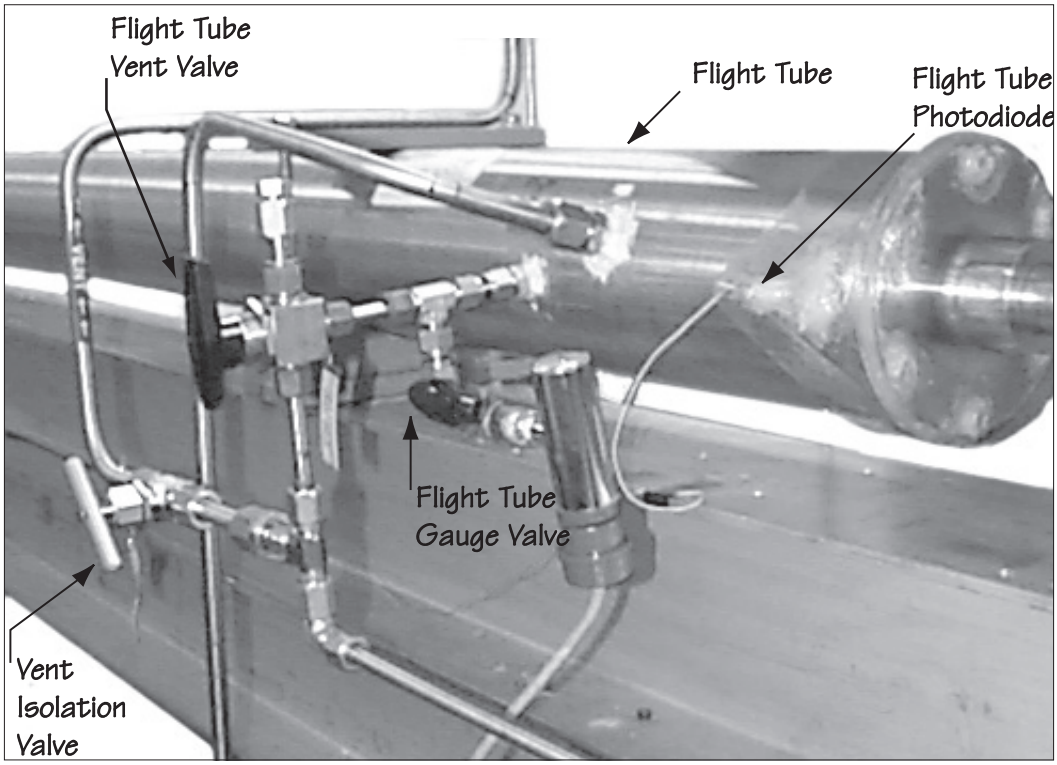


Figure 4.1-20
Flight Tube Valves

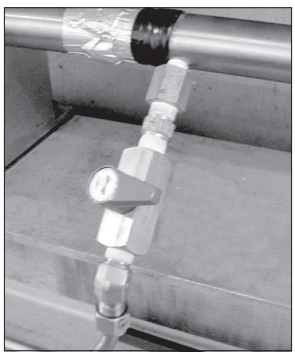


Figure 4.1-21.
Pump Tube Valve (green)

4.1.17.2. On the back of the gun, **open** the **Pump Tube Vent Valve** (Figure 4.1-1) and the **Vent Isolation Valve** (Figure 4.1-20).

4.1.17.3. On the gun control panel (Figure 4.1-22), **open** the **GN_2/GH_2 Supply Valve** and the **GN_2/GH_2 Gauge Valve.**

4.1.17.4. On the east range wall (Figures 4.1-14), **open** the **GN_2 Supply Valve** for 30 seconds; then **close** the valve.

4.1.17.5. On the east range wall, **lift** the safety cover over the **GH_2 Supply Valve** (Figure 4.1-23). **Open** the **GH_2 Supply Valve** for 10 seconds, then **close** the valve.

4.1.17.6. On the east range wall, **open** the **GN_2 Supply Valve** for 30 seconds, then **close** the valve. This will sweep GH_2 from the system.

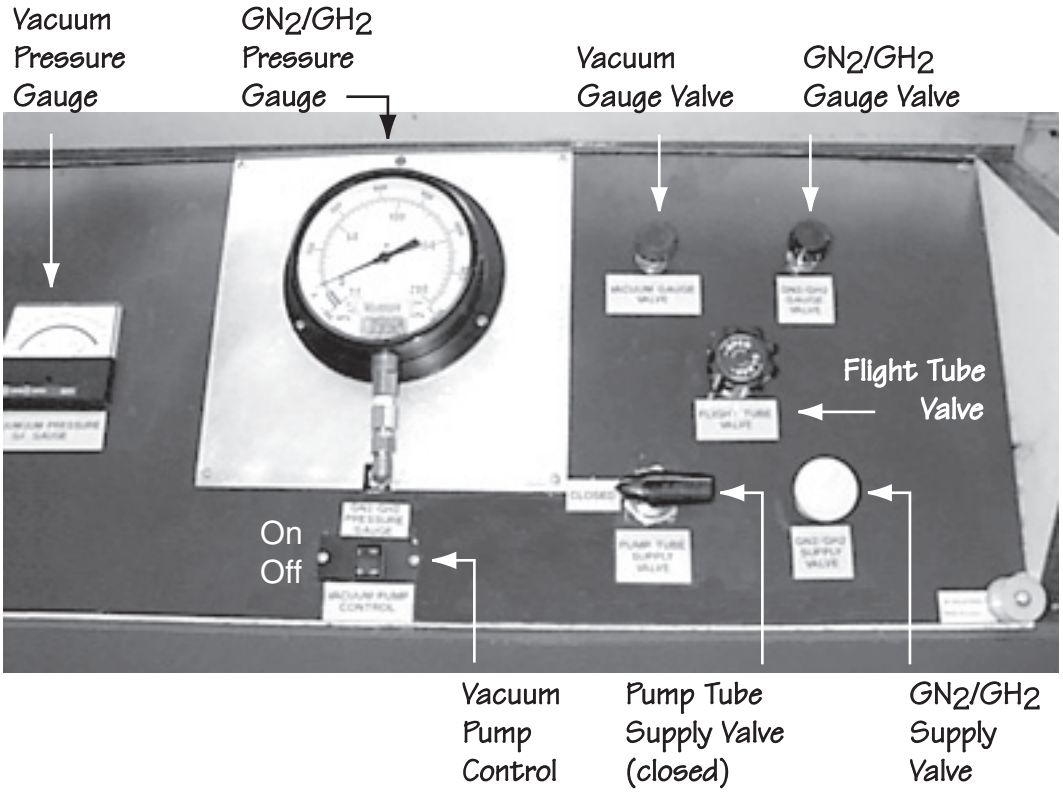


Figure 4.1-22.
MLGG Control Panel

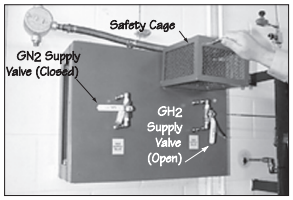


Figure 4.1-23.
GH_2 Supply Valve Opened

4.1.17.9. On the back of the gun, **close** the **Pump Tube Vent Valve** ONLY. (**Refer** to Figure 4.1-1.)

4.1.17.10. On the back of the gun, **open** the **Pump Tube Valve** (green).

4.1.18. At the control panel, **turn on** the vacuum pump by placing the **Vacuum Pump Control** toggle switch in the **ON** position (Figure 4.1-22).

4.1.19. On the control panel, **open** the **Flight Tube Valve** (Figure 4.1-22). **Evacuate** the target chamber and flight tube until the **Vacuum Pressure Gauge** reads 15 torr.

4.1.20. On the control panel, **close** the **Flight Tube Valve.**

4.1.21. On the control panel, open the **Pump Tube Supply Valve.**

4.1.22. On the control panel, open the **Vacuum Gauge Valve** by turning the knob clockwise. **Evacuate** the breech side of the chamber to 200 mtorr or less.

4.1.23. **Turn on** the oscilloscope, and **push** the trigger button **ON**. On the oscilloscope screen, the word "TRIG" will appear.

4.2 Preload Inspection

Note: Wait at least 15 minutes after pump tube evacuation has begun before performing the preload inspection.

Personnell **shall perform** the following procedures:

4.2.1. In the gun room, **ensure** that the hydrogen monitor (Figure 4.1-13) is operational.

4.2.2. In the control room, **ensure** that the interlock switch (Figures 4.2-1 and 4.2-2) is in the OFF position. The interlock switch is located on a breaker box labeled "Crane Disconnect." When the switch arm is down, the interlock function is off.

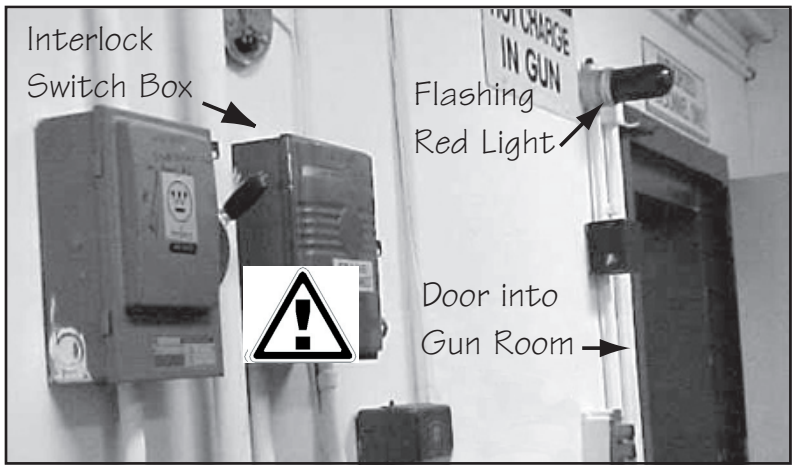


Figure 4.2-1
Locations of interlock switch, flashing red light, and gun room door

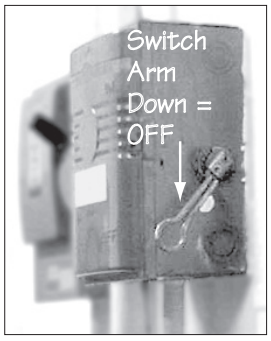


Figure 4.2-2.
Interlock switch in OFF position

4.2.3. In the control room, **turn on the flashing red warning light** (Figure 4.2-3).

Figure 4.2-3.
Flashing red warning light

4.2.4. **In the control room, place** the chain and danger sign across the gun room door (Figure 4.2-4). **Close** and **lock** all doors to facility: north rollup door, east door to outside, east door from control room into Building 4612 hallway.

4.2.5. **Inspect** the MLGG before charge preparation and loading, using the Pre-Load Inspection Checklist (Part A of Figure 7.2-2). The entire, completed checklist for each shot shall be maintained as a quality record.

Figure 4.2-4
Chain across gun room door

4.3 Charge Preparation

Part B of Figure 7.2-2 presents the charge preparation steps in checklist form. The entire checklist for each shot shall be maintained as a quality record. Personnel shall perform the following procedures:

CAUTION: Only a certified Range Operator and one explosive-certified Range Assistant are allowed in the preparation area in the gun room during charge preparation and loading.

CAUTION: Charge preparation shall be performed on the grounded, non-sparking table in Room 1000.

CAUTION: **Remove** all jewelry, wrist watches, keys, *etc.,* before preparing the charge.

CAUTION: Wear face shields and wrist stats when preparing and loading a charge. **Attach** wrist stats to ground points at the preparation table in Room 1000 and at the loading table in Room 1000.

Note: After the charge is loaded, no one is permitted in the gun room without permission of the Range Operator or Range Engineer.

Note: The person responsible for a particular step is identified immediately following the step number.

4.3.1. **Don face shields.**

4.3.2. **Don** wrist stats.

CAUTION: Before performing the following steps, **ensure** that wrist stats are connected to ground.

4.3.3. **Test** wrist straps with a calibrated meter to ensure that the resistivity of the grounding system between the wearer and the wrist ground clip is between 25,000 ohm and 1 Mohm.

4.3.4. **Ensure** that the grounding table resistivity is between 25,000 ohm and 1 Mohm.

4.3.5. Range Operator or Range Assistant: **Determine** the powder charge weight from the MLGG Data Sheet (*Amount* field) (Figure 7.2--5) submitted by the Range Operator or the Range Engineer.

4.3.6. Range Operator or Range Assistant: **Measure** the appropriate amount of 1.3C smokeless powder, as described below:

4.3.6.1. **Remove** a container of 1.3C smokeless powder from the magazine (yellow cabinet labeled "Explosives. Keep Fire Away"). **Place** smokeless powder container on the loading table.

4.3.6.2. **Connect** wrist stats to ground. **Place** weighing dish on scales, and **zero out** the scales.

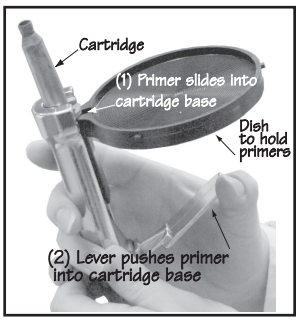


Figure 4.3-1. Loading primer into cartridge casing

4.3.6.3. **Pour** enough powder into the dish on the scales to obtain the required weight.

4.3.6.4. **Return** the powder container to the magazine, and **lock** the magazine.

4.3.7. Range Operator: **Press** a new primer into the cartridge, using the Auto Prime Primer Loader (Figure 4.3-1).

4.3.8. Range Operator: **Pour** the weighed powder into a cartridge shell, using funnel.

4.3.9. Range Operator: **Pack** wadding (~1/8 sheet of toilet paper) on top of the powder.

4.3.10. Range Operator and Range Assistant: **Disconnect** wrist straps, and **carry** the charge to the gun.

4.3.11. Range Operator: **Place** the cartridge into the open breech (Figure 4.3-2).

WARNING: WHILE INSERTING THE BOLT AND AFTER THE BOLT IS INSERTED, DO NOT STAND OR WALK BEHIND THE BREECH.

4.3.12. Range Operator: **Slide** in the breech bolt, and **lock** it into place (Figure 4.3-3). **Set** the safety on the gun by pushing the safety lever away from the target chamber.

Note: The Range Engineer and Range Operator remain in the gun room during firing.

4.4 Firing

Note: Only the Range Engineer or the Range Operator shall perform the Firing Procedure.

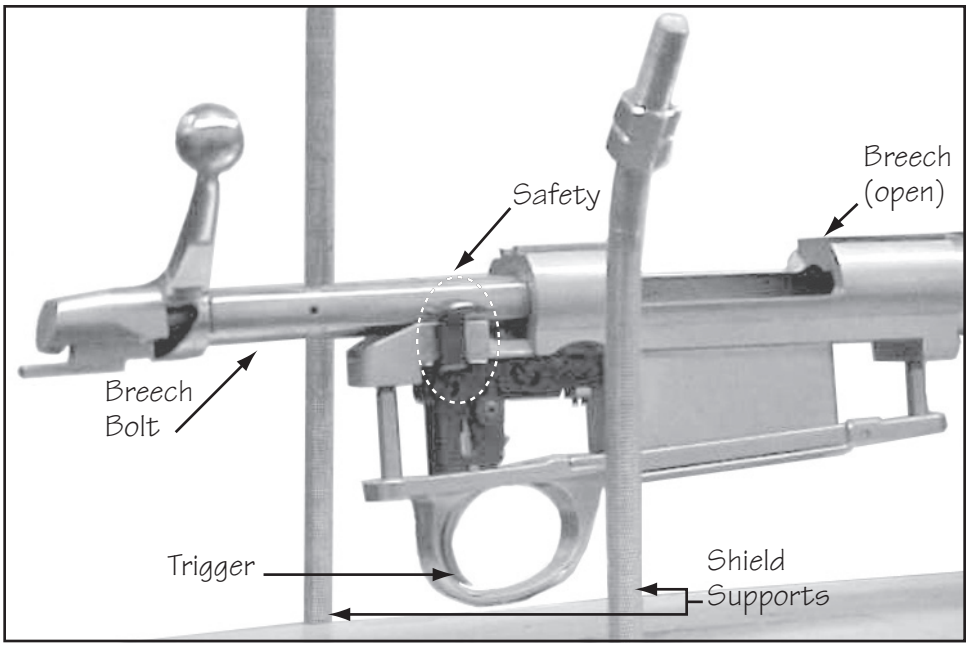


Figure 4.3-2.
Open breech with breech bolt inserted but not locked in place

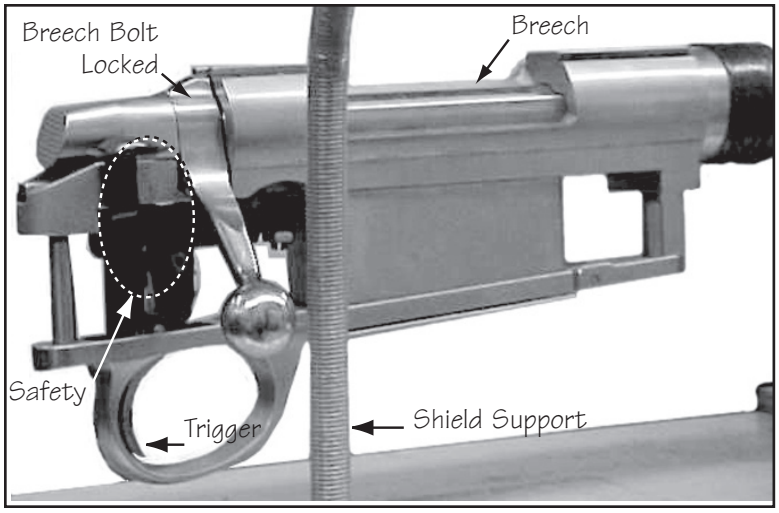


Figure 4.3-3.
Breech with breech bolt locked

Personnel **shall perform** the following steps to fire the MLGG. Figure 7.2-3 presents these steps in a checklist form. The completed checklist for each shot **shall** be maintained as a record.

4.4.1. On the control panel, **close** the **Pump Tube Supply Valve.**

4.4.2. On the control panel, **turn off** the vacuum pump by toggling the **Vacuum Pump Control** switch to the **OFF** position. **Ensure** that the system maintains good pressure.

4.4.3. On the control panel, **close** the **Vacuum Gauge Valve** and the **GN_2/GH_2 Gauge Valve.**

4.4.4. On the east range wall, **lift** the safety cover, and **open** the **GH_2 Supply Valve.**

4.4.5. On the control panel, **slowly open** the **GN_2/GH_2 Gauge Valve** to the desired pressure.

4.4.6. On the control panel, **close** the **GN_2/GH_2 Gauge Valve** and the **GN_2/GH_2 Supply Valve**.

4.4.7. On the east range wall, **close** the **GH_2 Supply Valve**. **Ensure** that the safety cover is closed.

4.4.8. On the back of the gun, **close** the **Pump Tube Valve**.

4.4.9. **Ensure** that the oscilloscope is set to record data.

4.4.10. Range Engineer: **Take** position beside the telephone.

4.4.11. **Release** the safety on the breech.

WARNING: WHEN FIRING THE GUN, WORK FROM THE SIDE. NEVER STAND DIRECTLY BEHIND THE BREECH.

4.4.12. **Fire** the gun by pulling the trigger.

Note: *If the MLGG misfires,* **release** the hydrogen pressure by opening the **Pump Tube Valve** (green) on the back side of the gun. Then, **perform** the Misfire Procedure (section 4.7).

4.4.13. After a successful firing, **open** the east door beside the MLGG, leading to the outside to allow the smoke and odor to dissipate.

4.4.14. **Remove** the chain across the door into the control room.

4.4.15. **Turn off** the flashing red warning light in the control room.

4.5 Post-Firing System Safing

WARNING: AFTER THE MLGG HAS BEEN FIRED, NO ONE SHALL ENTER THE GUN ROOM WITHOUT PERMISSION FROM THE RANGE ENGINEER OR RANGE OPERATOR.

The MLGG system is divided into two sections for the safing procedure. The first section is from the AR section to the target chamber. The second extends from the breech to the AR section. The piston, lodged in the AR section after firing, serves to isolate the two areas. Personnel **shall perform** the following procedures:

Note: The Range Operator is responsible for safing the MLGG system in preparation for cleaning.

4.5.1. **Perform** the following steps to purge the flight tube after firing:

4.5.1.1. At the back of the gun, **open** the **Pump Tube Valve** (green) and the **Pump Tube Vent Valve**.

4.5.1.2. On the control panel, **open** the **GN2/GH2 Supply Gauge** and the **GN2/GH2 Gauge Valve**.

4.5.1.3. At the back of the gun, **close** the **Vent Isolation Valve.**

4.5.1.4. On the east range wall, **open** the **GN_2 Supply Valve** for 30 seconds; then **close** the valve.

4.5.1.5. At the back of the gun, **open** the **Vent Isolation Valve.**

4.5.1.6. **Listen** for all GN_2 to vent; then close the **Vent Isolation Valve.**

4.5.2. **Repeat** step 4.5.1 completely two more times. After the last purge, **leave** the **Vent Isolation Valve** open.

4.5.3. **Open** the **Flight Tube Vent Valve,** and **ensure** that the Flight Tube is completely vented.

4.5.4. **Open** all valves on the control panel.

WARNING: WHEN REMOVING THE BREECH BOLT, WORK FROM THE SIDE. NEVER STAND DIRECTLY BEHIND THE BREECH.

4.5.5. **Remove** the breech bolt.

4.5.6. **Remove** the shield.

4.5.7. **Remove** and **discard** the cartridge.

4.5.8. At the back of the gun, **disconnect** the pump tube supply line.

4.5.9. **Announce** that the breech end of the system is safe and that cleaning may proceed.

4.5.10. *If this is the last test of the day,* **perform** the following:

4.5.10.1. **Close** the **GN_2 Supply Valves** on the GN_2 cart and outside wall.

4.5.10.2. **Open** the **GN_2 Bleed Valves** on the outside wall to bleed off GN_2 in the line.

4.5.10.3. At the K-bottle station, **close** the hydrogen K-bottle main valve.

4.5.10.4. At the K-bottle station, **ensure** that the **GH_2 Bleed Valve** is closed.

4.6 MLGG System Cleaning

Personnel **shall perform** the following steps to clean the MLGG. Figure 7.2-4 presents these steps in a checklist form. The completed system cleaning checklist for each shot is not required as a quality record.

4.6.1. **Disassemble** the gun by performing section assembly (steps 4.1.3 and 4.1.4 above) in reverse order:

- **Remove** tops of pillow blocks.
- **Remove** bolts on pump tube side of AR section.
- **Separate** pump tube from AR section.
- **Remove** AR section.
- **Remove** flange from flight tube side of AR section.
- **Disconnect** clam shell from flight tube.
- **Disassemble** clam shell.

Figure 4.6.
Piston removed from AR section after firing.

4.6.2. **Remove** piston from AR section by tapping it firmly with a small rod. (Figure 4.6 shows the deformation of a spent piston.)

4.6.3. **Remove** the target assembly from the target chamber, and **disassemble** (**refer** to step 4.1.2 above, if necessary).

4.6.4. **Remove** any debris found in the target chamber.

4.6.5. **Clean** the breech area with alcohol.

4.6.6. **Grease** the clam shell O-rings with vacuum grease.

4.6.7. **Discard** the barrel.

4.6.8. **Clean** the AR section with alcohol.

4.7 Misfire Procedure

If the MLGG misfires, personnel **shall perform** the following actions:

4.7.1. **Wait** 30 minutes before performing step 4.7.2.

4.7.2. **Don** a face shield.

WARNING: WHEN REMOVING THE BREECH BOLT, WORK FROM THE SIDE. NEVER STAND DIRECTLY BEHIND THE BREECH.

4.7.3. **Open** the breech bolt, and **remove** it.

4.7.4. Carefully **remove** the cartridge.

4.7.5. **Examine** the cartridge to determine whether the primer was hit.

4.7.5.1. *If the primer was hit,* **discard** the cartridge (**see** Note below for procedure), and **begin** the charge preparation procedure at step 4.3.2, measuring the black powder charge.

Note: *If wrist stats were disconnected for any reason,* it is especially critical that the charge preparation procedure be repeated from step 4.3.2.

Note: Discard this cartridge by placing it in the wooden box in the cabinet designated for such cartridges. **Call** the U.S. Army Explosive Storage and Demolition Branch to come pick up the wooden box containing the cartridge.

4.7.5.2. *If the primer was not hit,* **resume** the charge preparation procedure at step 4.3.10, ensuring that the cartridge is correctly installed.

5.0 Notes

Custodians for EM50-OWI-029	
Master List and Document Control	EM50 Management Support Assistant
Alternate Document Control	EM50 ISO Representative
Records	Environmental Effects Branch ISO Representative
Calibration	Environmental Effects Branch Calibration Contact
Memoranda	Environmental Effects Branch ISO Representative

6.0 Safety Precautions and Warning Notes

6.1 Hazards

> **Warning**
> Death, severe personal injury, or loss of major equipment may result if maintenance or operating procedures, techniques, restrictions, etc., are not followed exactly.

The nature of operating the MLGG involves several potential hazards, including:

- Loading of gaseous hydrogen
- Storage, transportation, and handling of black powder propellant 1.3C (explosive powder)
- Preparation and loading of explosive charges and primers.

6.2 Safety Precautions

6.2.1. Preparation and firing of the MLGG shall be supervised by a Range Operator in accordance with this OWI. **The Range Operator's authority includes the right to order off the range anyone who interferes with or contravenes safety precautions.** The Range Operator may also postpone or cancel any firing in the interest of safety.

6.2.2. Personnel **shall** p**lan** MLGG system setup, testing, and shutdown so that at least one certified Range Operator and one explosive-certified person are in attendance during MLGG loading and firing operations.

6.2.3. No more than 8 people shall be in the MLGG control room during charge preparation, gas loading, and MLGG firing.

6.2.4. No more than 1 trainee at a time shall participate in firing the MLGG.

6.2.5. In accordance with Occupational Safety and Health Administration requirements, personnel **shall read** the Materials Safety Data Sheets (MSDSs) for all chemicals used or encountered during testing and shall **read the test material's MSDS to ensure familiarity with all safety precautions associated with the material.**

6.2.6. **Smoking shall not be permitted** in Building 4612.

6.2.7. Personnel **shall wear** safety apparel appropriate for MLGG operations:
- Face shields when preparing and loading a charge
- Wrist stats connected to ground when preparing and loading a charge.
- Cotton clothes or clothes provided for use in gun room area.

6.2.8. Personnel **shall check** the hydrogen monitor before performing the initial MLGG system preparation and pre-load inspection. *If the alarm system is not operational,* personnel **shall not continue** with these activities.

6.2.9. Personnel **shall** always **stand to the side** of the MLGG breech and shall **never walk or stand behind the breech.**

6.2.10. All visits to the MLGG area **shall** be authorized by the Range Lead or Range Engineer. Visitors **shall** enter the area through the control room and check in with the Range Operator. The Range Operator is responsible for ensuring that all visitors who tour the range, especially before a firing, have been made aware of the safety precautions involved.

6.2.11. Personnel shall **turn on** the flashing red light at the control room before loading the charge into the gun breech. The warning signal **shall** remain on until the firing has been completed and the range area is clear to all personnel, as determined by the Range Operator.

6.2.12. No propellant or hydrogen gas **shall** be loaded into the MLGG until the gun room has been cleared of all personnel, with the exception of the Range Operator and one certified Range Assistant or trainee. No other personnel **shall** be permitted into the gun room during or after charge loading until the firing sequence has been completed. When the MLGG gun room door is closed, the interlock system is energized, and an audible signal sounds for 2 to 3 seconds.

6.2.13. *If, during firing, a range structure sustains damage or some other anomaly occurs,* no further firing **shall** be carried out until the damage is repaired or the proper corrective action has been taken. The Range Lead or Range Engineer **shall** permit further operations only when satisfied that personnel or equipment will not be endangered.

6.2.14. The fire hazard symbol is located outside the MLGG rooms at each door.

6.3 Special Hazards Associated with Compressed Gases and Liquids

6.3.1. All operations involving compressed gases and liquids shall be conducted with at least two people in visual contact in the facility.

6.3.2. All operating personnel shall be instructed on the nature of hazards associated with compressed gases and liquids.

6.3.3. Before removal of any component of the system for servicing, the operator shall secure and inspect the system to ensure that no unsafe condition exists.

6.3.4. Personnel shall perform continuous monitoring, *e.g.,* check operating pressures, look for leaks, listen for unusual noises, during all operations.

6.4 Emergency Shutdown

Personnel **shall perform** the following procedures:

6.4.1. **Lift** the cage around the **GH_2 Supply Valve** on wall or range. This will turn off the electrical supply to the gun.

6.4.2. **Turn off** the gas supply from the GH_2 K-bottle.

6.5 Accident Reporting

6.5.1. From a safe location, personnel **shall immediately call 911** and **notify** the EM50 Branch Chief.

6.5.2. From a safe location, the *EM50 Branch Chief* **shall immediately report** the accident to the NASA Safety Monitor and the appropriate supervisor(s).

6.6 Emergency Response Plan

Emergency procedures and plans for Building 4612 are incorporated into the OWIs and are stated in MPR 1040.3. *MSFC Emergency Plan*. Plans **shall** be modified if operations change in a significant manner.

6.7 Mishap Reporting

"Each employee is responsible for reporting emergencies, unsafe or potentially unsafe conditions, mishaps and close calls in the workplace.[1]"

Personnel **shall report** all mishaps occurring in the MLGG control and gun rooms in Building 4612 to the *Range Lead*, who shall **report** the mishap to the *area coordinator/Safety Monitor,* who shall **report** the mishap or close call in accordance with MWI 8621.1, *Close Call and Mishap/Incident Reporting and Investigation Program*. Specifically,

- For all Type A & B mishaps, *the area coordinator/Safety Monitor* shall immediately**initiate** an initial verbal report to the Center Director and S&MA Director.

Note for contractor employees: In the absence of the Range Lead and the area coordinator/Safety Monitor or other NASA employee, any employee is

[1] MWI 8621.1 *Close Call and Mishap/Incident Reporting and Investigation Program.* March 27, 2000. pg. 7.

authorized to initiate verbal notification of the Center Director and S&MA Director immediately

- For all mishaps and close calls, a flash report shall be generated within 4 hours of the mishap occurrence. The *employee reporting the mishap or close call* **shall notify** his/her supervisor immediately. The *employee's immediate supervisor* **shall call** 544-4357, Option 0, to generate the flash report. In addition, the *employee's immediate supervisor* **shall submit** NASA Form 1627 to S&MA within 6 calendar days. All mishaps **shall** be reported in accordance with MWI 8621.1, *Close Call and Mishap/Incident Reporting and Investigation Program.*

7.0 Attachments, Data, Reports, and Forms

7.1 Reports

Testing **shall** be reported in weekly notes. A final test report **shall** be sent to the test requester at the end of the test series, unless otherwise requested. Test results are also contained in a database maintained by the Range Engineer.

7.2 Forms

7.2.1. System Initial Preparation Checklist: Figure 7.2-1 shows a representative System Initial Preparation Checklist. This checklist is not considered a record and does not require archiving.

7.2.2. Pre-Load Inspection and Charge Preparation Checklist: Figure 7.2-2 shows a representative Pre-Load Inspection and Charge Preparation Checklist. This completed checklist for each shot **shall** be maintained as a record.

7.2.3. MLGG Firing/Safing Procedure Checklist: Figure 7.2-3 shows a representative MLGG Firing/Safing Procedure Checklist. A completed MLGG Firing/Safing Procedure Checklist for each shot **shall** be maintained as a record.

7.2.4. System Cleaning Checklist: Figure 7.2-4 shows a representative System Cleaning Checklist. This checklist is not considered a record and does not require archiving.

7.2.5. Test Data Sheet: Figure 7.2-5 shows a sample MLGG Test Data Sheet. Test Data Sheets **shall** be maintained as records.

7.2.6. Work Request: Figure 7.2-6 shows a representative MLGG Work Request. Work Requests **shall** be maintained as records.

Figure 7.2-1.
System Initial Preparation Checklist (sample)

System Initial Preparation Checklist
(Refer to section 4.1 for detailed instructions.)

Control Room

___ 1. Interlock switch set to OFF

MLGG Room

___ 2. All valves on control panel closed (step 4.1.1)
___ 3. Target assembly prepared and installed (step 4.1.2)
___ 4. Target chamber secured (step 4.1.2)
___ 5. Clam shell assembled and attached to flight tube (step 4.1.3)
- ___ 5a. Barrel cleaned (step 4.1.3.1)
- ___ 5b. Projectile and sabot (or slug) loaded into barrel (step 4.1.3.2)
- ___ 5c. Barrel placed wit h projectile end toward breech (step 4.1.3.3)
- ___ 5d. Barrel taped (step 4.1.3.4)
- ___ 5e. Clam shell halves mated; screws torqued to 15 ft. lb (step 4.1.3.5)
- ___ 5f. Clam shell assembly placed in pillow blocks (step 4.1.3.6)
- ___ 5g. O-rings inserted in assembly grooves facing flight tube (step 4.1.3.7)
- ___ 5h. Muzzle adapter attached to flight tube end of assembly (step 4.1.3.8)
- ___ 5i. Muzzle adapter threaded to flight tube (step 4.1.3.9)
- ___ 5j. Proper AR flange attached to clam shell assembly (step 4.1.3.10)

___ 6 Pump tube/AR section assembled and installed (step 4.1.4)
- ___ 6a. Burst disk installed in AR section (step 4.1.4.1)
- ___ 6b. Pump tube positioned on pillow blocks (step 4.1.4.2)
- ___ 6c. Proper AR flange attached to pump tube (step 4.1.4.3)
- ___ 6d. AR section positioned between clam shell and pump tube with burst disk toward clam shell assembly (step 4.1.4.4)
- ___ 6e. Pump tube flange inserted into AR section (step 4.1.4.5)
- ___ 6e. AR bolts inserted into flanges and attached fingertight (step 4.1.4.6)
- ___ 6f. Pump tube supply line attached (step 4.1.4.7)
- ___ 6g. Pump tube, AR section, clam shell assembly aligned (flange bolts torqued to 50 ft-lb) (step 4.1.4.8)
- ___ 6h. Pillow block tops attached (step 4.1.4.9)
- ___ 6i. Piston installed (step 4.1.4.10)

___ 7. Breech bolt inserted (step 4.1.5)
___ 8. Control shield positioned over gun (step 4.1.6)
___ 9. Hydrogen monitor operational. If not, do not proceed. (step 4.1.8)
___ 10. GN_2 and GH_2 Supply Valves (on wall) closed (step 4.1.9)
___ 11. GN_2 cart cylinder (outside) registers 100 psi (step 4.1.10)
___ 12. GN_2 Supply Valve (on cart and outside wall) opened (step 4.1.11)
___ 13. GN_2 pressure 25 psig on GN_2 Purge Supply Panel (on wall) (step 4.1.12)
___ 14. GH_2 Bleed Valve (at bottle station) closed (step. 4.1.13)
___ 15. GH_2 K-bottle pressure 200 psi (step. 4.1.15)
___ 16. GH_2 K-bottle regulator set to desire test pressure (step 4.1.16)
___ 17. GH_2 lines purged (step 4.1.17)
- ___ 17a. On gun, Flight Tube Vent Valve, Pump Tube Valve closed (step 4.1.17.1)
- ___ 17b. On gun, Pump Tube Vent Valve, Vent Isolation Valve opened (step 4.1.17.2)
- ___ 17c. On control panel, GN_2/GH_2 Supply and GN_2/GH_2 Gauge Valves opened (step 4.1.17.3)
- 17d. On wall, GN_2 Supply Valve opened 30 sec; closed (step 4.1.17.4)
- ___ 17e. On wall, GH_2 Supply Valve opened 10 sec; closed (step 4.1.17.5)
- ___ 17f. On wall, GN_2 Supply Valve opened 30 sec; closed (step 4.1.17.6)
- ___ 17g. On gun, Pump Tube Vent Valve closed (step 4.1.17.7)
- ___ 17h. On gun, Pump Tube Valve opened (step 4.1.17.8)

___ 18. Vacuum Pump turned on (step 4.1.18)
___ 19. On control panel, Flight Tube Valve opened; target chamber, flight tube evacuated to 15 torr (step 4. 1. 19)
20. On control panel, Flight Tube Valve closed (step 4. 1. 20)
___ 21. On control panel, Pump Tube Supply Valve opened (step 4. 1. 21)
___ 22. On control panel, Vacuum Gauge Valve opened; breech end evacuated to 200 mtorr (step 4. 1. 22)
23. Oscilloscope turned on; trigger button pushed (step 4.1.23)
___

1/05

Note: Representative Checklist

Pre-Load Inspection and Charge Preparation Checklist

Shot Number				Step Number	Step Description
					Part A: Pre-Load Inspection
				1	Hydrogen monitor operational (step 4.2.1)
				2	Interlock switch OFF (step 4.2.2)
				3	Flashing red light ON (step 4.2.3)
				4	Pump tube and clam shell aligned with AR section • AR bolts torqued to 50 ft-lb • Pillow blocks bolted
				5	Three doors closed and locked (step 4.2.4) • North door (rollup, opening to outside) • East door (beside MLGG, opening to outside) • East door (opening into hallway from control room)
				6	Chain secured across gun room entrance (step 4.2.4)
				7	Vacuum Pressure Gauge indicating 15 torr
				8	Oscilloscope ON and in TRIGGER mode (step 4.1.23)
				9	No unauthorized persons in gun room
					Part B: Charge Preparation
				10	Face shield and wrist stats donned (steps 4.3.1, 4.3.2)
				11	Wrist stats tested to ensure sufficient resistivity (25,000 ohm - 1 Mohm) (step 4.3.3)
				12 13	Table grounding tested to ensure sufficient resistivity (25,000 ohm - 1 Mohm) (step 4.3.4)
				14	Charge determined from MLGG Data Sheet (step 4.3.5)
				15	Black powder removed from magazine (step 4.3.6.1)
				16	Wrist stats connected to ground (step 4.3.6.2)
				17	Scale zeroed out with weighing dish (step 4.3.6.2)
				18	Powder measured (step 4.3.6.3)
				19	Powder container returned to magazine; magazine locked (step 4.3.6.2)
				20	Primer pressed into cartridge (step 4.3.7)
				21	Weighed powder funneled into cartridge shell (step 4.3.8)
				22	Wadding packed on top of powder (step 4.3.9)
				23	Wrist stats disconnected (step 4.3.10)
				24	Cartridge placed in open breech (step 4.3.11)
				25	Breech bolt slid in and locked into place (step 4.3.12)
				26	Safety on (pushed away from the target chamber) (step 4.3.12)

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Note: Representative Checklist. Refer to Forms Master List for current version.

Figure 7.2-2. Pre-Load Inspection and Charge Preparation Checklist (sample)

Figure 7.2-3.
MLGG Firing/Safing Procedure Checklist (sample)

MLGG Firing/Safing Procedure Checklist
Range Engineer or Range Operator only

Shot Number				Step	Step Description
					FiringChecklist
				1	Pump Tube Supply Valve closed (step 4.4.1)
				2	Vacuum Pump Control switch toggled OFF (step 4.4.2)
				3	Vacuum Gauge Valve (control panel) closed (step 4.4.3)
				4	GN_2/GH_2 Gauge Valve (control panel) closed (step 4.4.3)
				5	GH_2 Supply Valve (on wall) opened (step 4.4.4)
				6	GN_2/GH_2 Gauge Valve (control panel) opened slowly (step 4.4.5)
				7	Desired pressure reached (step 4.4.5)
				8	GN_2/GH_2 Gauge Valve (control panel) closed (step 4.4.6)
				9	GN_2/GH_2 Supply Valve (control panel) closed (step 4.4.6)
				10	GH_2 Supply Valve (on wall) closed (step 4.4.7)
				11	Safety Cover over GH_2 Supply Valve closed (step 4.4.7)
				12	Pump Tube Valve closed (step 4.4.8)
				13	Oscilloscope set to record data (step 4.4.9)
				14	Range Engineer positioned by phone (step 4.4.10)
				15	Safety released (step 4.4.11)
				16	Gun fired (Stand at side; never behind breech) (step 4.4.12)
				17	East door opened (step 4.4.13)
				18	Chain removed from control room door (step 4.4.14)
				19	Flashing red light in control room turned off (step 4.4.15)
					Safing Checklist (Range Operator)
				20	Flight tube purged (step 4.5.1)
				20a	Pump Tube Valve (on gun) opened (step 4.5.1.1)
				20b	Pump Tube Vent Valve (on gun) opened (step 4.5.1.1)
				20c	Flight tube and pump tube completely vented
				20d	GN_2/GH_2 Supply Gauge (control panel) opened (step 4.5.1.2)
				20e	GN_2/GH_2 Gauge Valve (control panel) opened (step 4.5.1.2)
				20f	Vent Isolation Valve (on gun) closed (step 4.5.1.3)
				20g	GN_2 Supply Valve (on wall) opened 30 sec; closed (step 4.5.1.4)
				20h	Vent Isolation Valve (on gun) opened (step 4.5.1.5)
				20i	Vent Isolation Valve (on gun) closed after GN_2 vent (step 4.5.1.5)
				21	Flight tube purge repeated (step 4.5.2)
				22	Flight tube purge repeated again (step 4.5.2)
				23	Vent Isolation Valve left open after third purge (step 4.5.2)
				24	Flight Tube Vent Valve opened (step 4.5.3)
				25	All valves on control panel opened (step 4.5.4)
				26	Breech bolt removed (step 4.5.5)
				27	Shield removed (step 4.5.6)
				28	Cartidge removed and discarded (step 4.5.7)
				29	Pump tube supply line disconnected (step 4.5.8)
				30	Breech end of the system announced safe (step 4.5.9)
				31	*If last shot of day,*
				31a	GN_2 Supply Valves (cart and outside wall) closed (step 4.5.10.1)
				31b	GN_2 Bleed Valve (outside wall) opened (step 4.5.10.2)
				31c	H_2 K-bottle main valve closed (step 4.5.10.3)
				31d	GH_2 Bleed Valve (bottle station) closed (step 4.5.10.4)

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Note: Representative Checklist. Refer to Forms Master List for current version.

System Cleaning Checklist

___ 1. MLGG disassembled in reverse order of assembly. (steps 4.1.3, 4.1.4, 4.1.5)
___ 2. Piston removed. (step 4.6.2)
___ 3. Target assembly removed and disassembled. (step 4.1.2)
___ 4. Target chamber cleaned.
___ 5. Breech area cleaned.
___ 6. Clam shell disassembled, if not performed in Step 1. (step 4.1.3)
___ 7. Clam shell O-rings greased.
___ 8. AR section cleaned.
___ 9. Barrel discarded.

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Note: Representative Checklist for Illustration Only.

Figure 7.2-4.
System Cleaning Checklist (sample)

MLGG DATA SHEET

Range Engineer:
Range Operator:
Range Assistant:

SHOT #: **DATE:** **TIME:**

PROJECTILE TYPE:

MASS: **LENGTH:**

DIAMETER:

PISTON MASS: **LENGTH:**

DIAMETER: 0.221"

He PRESSURE:

PROPELLANT TYPE:

AMOUNT:

RANGE PRESSURE:

OSCILLOSCOPE: **Probe#1:** **Probe#2:**

PROJECTILE VELOCITY:

PHOTOS: before _____ **after** _____

NOTES:

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Note: Representative Data Sheet. Refer to Forms Master List for current version.

Figure 7.2-5
Test Data Sheet (sample)

Figure 7.2-6
Work Request Form
(sample)

Marshall Space Flight Center Organizational Work Instruction
EM50 Work Tracking and Data Control per EM50-OWI-002

Work Request #: **WR-EM50-xxx**
Date In (mm/dd/yy): **xx/xx/xx**
Date Out (mm/dd/yy): **xx/xx/xx**
Requester: **J. Doe**
Requester's Phone #: **4-xxxx** Requester's Tracking #: _____
Project: **NGST** Project Code: _____
Responsible Employee: **M. Doe**
Data Required: ☐ Testing ☐ Technical Review ☐ Other...

Description of Request:

Required Actions or Quality Records: Other

Special Instructions:

Notes:
Calibrated Equipment
ECN 000XXX Description Gas Gauge
ECN _____ Description _____
ECN _____ Description _____
ECN _____ Description _____
ECN _____ Description _____

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Note: Representative Work Request. Refer to Forms Master List for current version.

8.0 Records

8.1 Memoranda

Memoranda containing test results shall be retained for a minimum of 10 years by EM50.

8.2 Calibration Records

All equipment requiring calibration shall be in current calibration. MLGG equipment calibration is required every 6 months. Calibration records are maintained on site for a minimum of 1 year.

8.3 Maintenance of Records

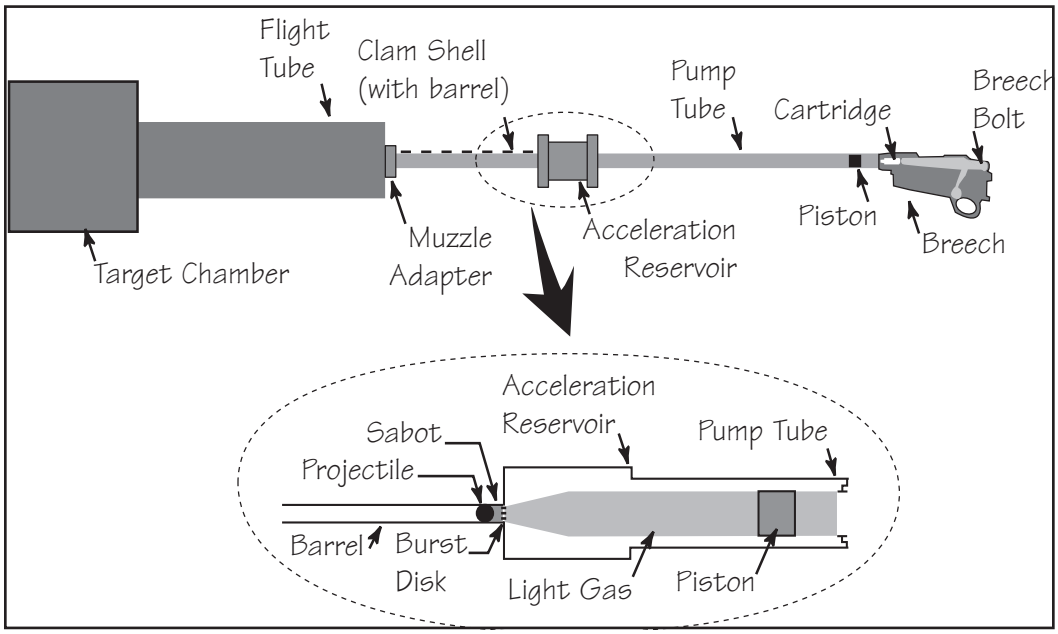
All records will be filed and indexed by report or memo number. These will be stored in a manner that will protect them, *e.g.*, in a test folder stored in a metal file cabinet.

9.0 Tools, Equipment, and Materials

9.1 Standard Configuration

The Micro Light Gas Gun system consists of a two-stage, 0.500-in. (12.7-mm) MLGG, and ancillary equipment. The total length of the MLGG system is 120 in. (300 cm) and includes an 18-in. (45-cm) long pump tube, a 16-in. (40-cm) long barrel, and an 86-in. (215-cm) long flight tube. As is the case with all light gas guns, the MLGG pump tube diameter is larger than that of the barrel. The diameter tapers from 0.25 in. (6.25 mm) in the pump tube to 0.125 mm (0.005 in.) in the barrel. The Acceleration Reservoir fairs from the pump tube to launch tube diameters. Figure 9.1-1 illustrates the MLGG configuration, and Figures 9.1-2 through 9.1-4 are photographs of the gun. Figure 9.1-5 presents the control plumbing of the MLGG.

Figure 9.1-1.
MLGG Diagram



The MLGG firing sequence begins with the ignition of the powder in the cartridge. The powder gases drive the piston down the pump tube and into the Acceleration Reservoir, compressing the light gas. The increased gas pressure causes the burst disk to rupture, releasing the accelerated reservoir of light gas into the barrel, launching the projectile or slug through the muzzle and down the flight tube until it encounters the target. O-rings at either end of the clam shell assembly provide the gas pressure seals. The gun tube sections (pump tube, barrel, and flight tube) are unusually heavy to provide increased rigidity and recoil weight.

Sabots (containing projectiles) and slugs are the same size: approximately 0.125 in. (3.175 mm) in both length and diameter. Projectiles differ from slugs in that their size corresponds to the typical micrometeoroid and orbital debris, between 0.0157 and 0.039 in. (0.4 and 1 mm) (spherical), whereas the slugs mimic the damage caused by debris approximately 0.125 in. (3.175 mm) (spherical). Normally aluminum is

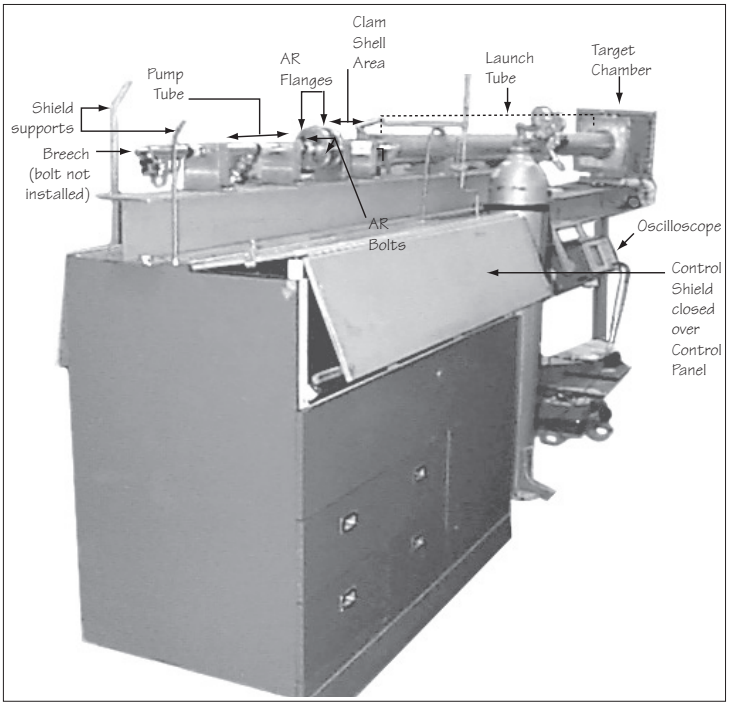


Figure 9.1-2.
MLGG with Shield Down

used to make the projectiles since the density (cylindrical) matches most closely with said space debris. The slugs are primarily used in calibration of the gun.

A typical MLGG target is 8x8 in. (20.32x20.32 cm). Each target is suspended between two threaded rods that connect the target frame and target shield.

The MLGG complex is located in Rooms 1002 and 1000 in Building 4612. The walls of the complex are constructed of 12-in. (30.48-cm) thick reinforced concrete. Lead steel doors open to the outside of the building. The control room is separated from the gun room by a lead steel door. The floor of the complex is 9-in. (22.86-cm) concrete reinforced with a steel grid.

Seven fixed air monitoring stations are used in the complex, although these are not involved in the MLGG operation. These stations simultaneously detect combustible gases, oxygen, hydrogen sulfide, and carbon monoxide and are components of the four-way alarm system.

For the MLGG, a hydrogen detector is located directly over the AR section, and the alarm system device and red warning light are located on the east range wall.

Figure 9.1-4.
MLGG Target Chamber

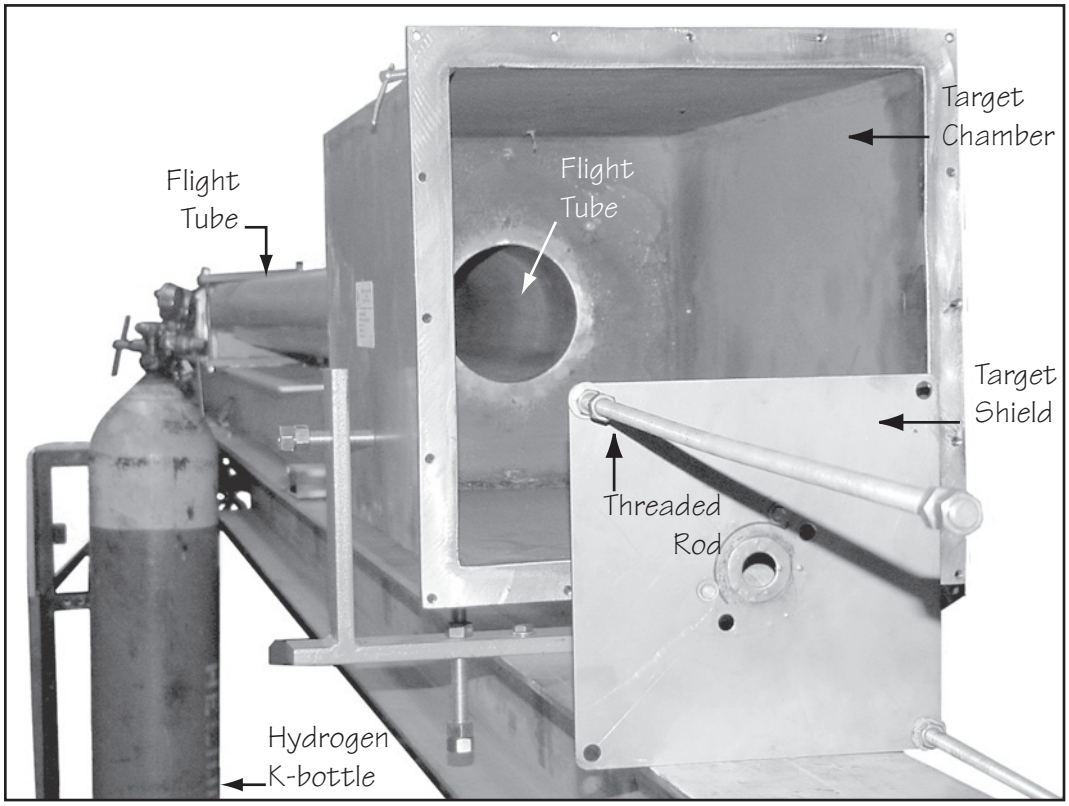
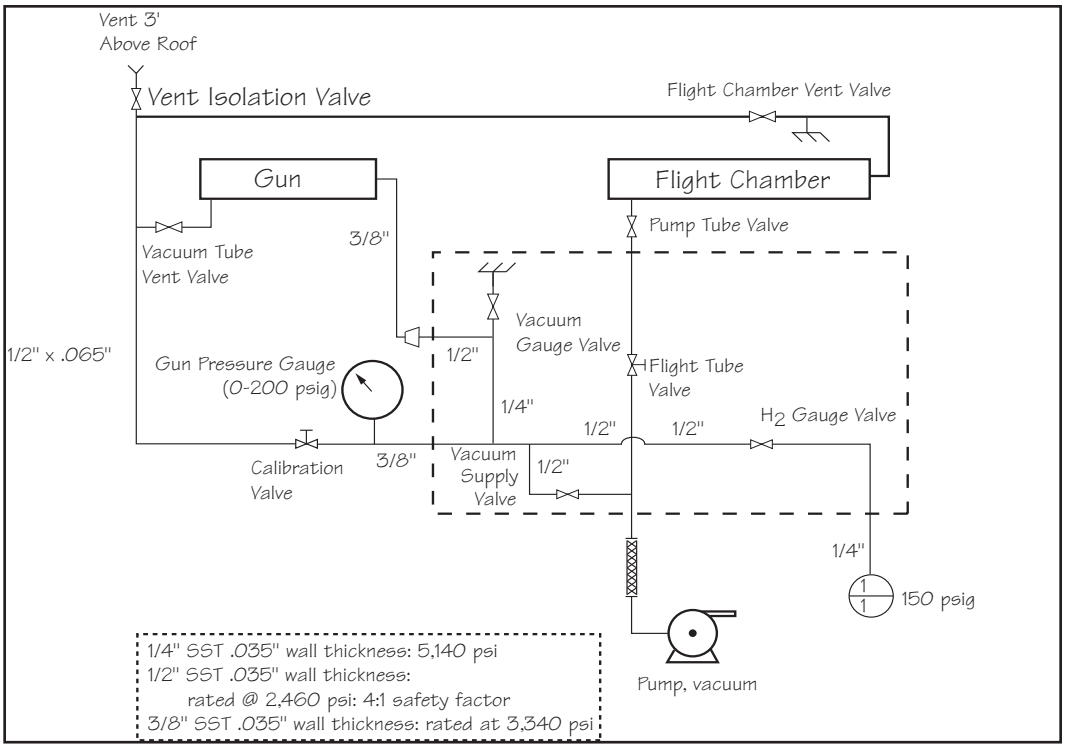


Figure 9.1-5.
MLGG Plumbing



9.2 Procedure for Deviations

Deviations to the baselined Micro Light Gas Gun configuration require NASA written approval. It is the responsibility of the Range Engineer to obtain the written approval. After written approval is received, the change shall be added to the appropriate Micro Light Gas Gun control file.

9.3 Required Tester Maintenance

The standard maintenance program for the MLGG and related control equipment consists of standard cleaning detailed in section 7.2 and as-required maintenance of the vacuum pump. In addition, the program involves a maintenance log, calibration, and a required spare parts inventory.

9.4 Calibration

The MLGG instrumentation is calibrated every 6 months. Calibrated equipment lists of all categories for this OWI are kept by the Range Engineer/Supervisor.

9.5 Required Spare Parts Inventory

Before beginning the MLGG activities, personnel shall **ensure** that there are spares for all pieces of test equipment, as listed in Table 9-1.

Table 9-1.
Spare Parts Inventory

Spare Parts Inventory		
Part	**Quantity**	**Drawing #/Description**
Projectile	10 of each type (nylon slugs, 0.4 mm, 0.6 mm, 0.8 mm, 0.9 mm, 1.0 mm)	
Barrel	50	
Piston	10 [0.222 in. (0.56 cm) dia., 0.5 in. (1.25 cm) long]	
Black Powder Propellant	1 bottle (1 lb)	1.3 explosive [Alliant Powder® Bullseye® (smokeless)]
Propellant Cartridge	50 (1 full box of 0.22-250 case)	
Primer	50 (1 full box)	

10.0 Personnel Training and Certification

The nature of work that occurs in the MSFC Impact Facility is complex and involves potential hazards; therefore, all activities covered by this OWI shall be performed only by certified MLGG personnel or under the direct supervision of personnel certified to do this work.

The Range Lead is responsible for the training and certification of MLGG operators. Individuals shall train under certified operators. No more than one trainee shall participate in firing of the MLGG. Training **shall** be overseen by the EM50 Management Support Assistant. The Range Lead may withdraw an operator's certification at any time.

Candidates for certification **shall** :

- Successfully complete an approved explosives handling safety course (NSTC 009 or equivalent)
- Participate directly in 10 MLGG firings
- Undergo an annual physical examination conducted by the medical facility at MSFC (or equivalent), including a hearing test.

Candidates for specific certifications shall perform the requirements listed below.

10.1 Range Engineer Certification

Certification as a Range Engineer requires that the candidate:

- Successfully complete requirements for the following certification specialities* as defined by MWI 3401.1, current revision:
  - Inert/Asphyxiate Gases and Liquids (see 10.5.1)
  - Hydrogen Handlers/Users
  - High-Pressure Systems (>150 psig)
  - Propellant and Explosive Handler/ESD (NSS 1740.12)
  - Propellant and Explosive User (NSS 1740.12)
- Successfully complete training in the following subjects*:
  - Use of Personal Protective Equipment
  - OSHA Record-Keeping Seminar (NSTC 047) or equivalent
  - Compressed Gas Trailer Safety (NSTC 0318)
  - Operation of the MLGG range
  - Explosive Safety Management and Engineering (NSTC 051)
  - Hazardous and Controlled Waste Generator
- Read this OWI thoroughly and sign a statement of reading and understanding the OWI. Each candidate shall be issued a personal copy of the OWI.
- Demonstrate proficiency in:
  - Preparing the MLGG system for firing

*Requirements for certification specialties/subjects are described in sections 10.5 and 10.6. .

- Preparing and loading charges
- Loading gaseous hydrogen
- Performing pre-firing inspections
- Performing the firing procedure
- Performing post-firing system safing
- Cleaning and minor maintenance of the MLGG.

The candidate's signed statement and training record shall constitute verification of certification. Certification will also be documented in a letter from the Range Lead to the Manager of the MPM Department with a copy to S&MA (QS01).

A candidate who successfully completes certification requirements **shall** be issued a certificate.

10.2 Range Operator Certification

Certification as a Range Operator requires that the candidate:

- Successfully complete requirements for the following certification specialities** as defined by MWI 3401.1, current revision:
  - High-Pressure Systems (>150 psig)
  - Propellant and Explosive User/ESD (NSS 1740.12)
- Successfully complete training in the following subjects**:
  - Use of Personal Protective Equipment
  - Hydrogen Safety (NSTC 037)
  - Operation of the MLGG range
  - Liquid Nitrogen Handler's Course (NSTC 314)
  - OSHA Record-Keeping Seminar (NSTC 047)
  - Compressed Gas Trailer Safety (NSTC 0318)
- Read this OWI thoroughly and sign a statement of reading and understanding the OWI. Each candidate shall be issued a personal copy of the OWI.
- Demonstrate proficiency in:
  - Preparing the MLGG system for firing
  - Preparing and loading charges
  - Loading gaseous hydrogen
  - Performing pre-firing inspections
  - Performing the firing procedure
  - Performing post-firing system safing
  - Cleaning and minor maintenance of the MLGG.

The candidate's signed statement and training record shall constitute verification of certification. Certification will also be documented in a letter from the Range Lead to the Manager of the MPM Department, with a copy to S&MA (QS01).

**Requirements for certification specialties/subjects are described in sections 10.5 and 10.6.

A candidate who successfully completes certification requirements **shall** be issued a certificate.

10.3 Range Assistant Certification

Certification as a Range Assistant requires that the candidate:

- Successfully complete training in the following subjects***:
  - Use of Personal Protective Equipment
  - Explosive Handlers (NSTC 009)
  - Safety in High-Pressure Systems (NSTC 315)
  - Liquid Nitrogen Handler's Course (NSTC 314)
  - Compressed Gas Trailer Safety (NSTC 0318)
- Read this OWI thoroughly and sign a statement of reading and understanding the OWI. Each candidate shall be issued a personal copy of the OWI.
- Demonstrate proficiency in:
  - Cleaning of the MLGG
  - Minor maintenance of the MLGG.

The candidate's signed statement and training record shall constitute verification of certification. Certification will also be documented in a letter from the Range Lead to the Manager of the MPM Department, with a copy to S&MA (QS01).

A candidate who successfully completes certification requirements **shall** be issued a certificate.

10.4 Recertifications

Operators **shall** be recertified every year. Recertification shall consist of successful completion of a short MLGG safety course and demonstration of the specific proficiencies listed above. Recertification **shall** be documented in the same manner as initial certification.

10.5 Certification Descriptions

10.5.1. Inert/Asphyxiate Gases and Liquids

- Cryogenic Safety (NSTC 313)
- Liquid Nitrogen Handler's Course (NSTC 314) or equivalent
- HazCom
- Physical

***Requirements for certification subjects are described in section 10.6.

- Type A OJT
- Refresher of all listed required every 2 years

10.5.2. Hydrogen Handlers/Users
- Cryogenic Safety (NSTC 313)
- Hydrogen Safety (NSTC 037) or equivalent
- HazCom
- Physical
- Type A On-the-Job Training (OJT)
- Refresher of all above required every 2 years

10.5.3. High Pressure Systems (>150 psig)
- Safety in High-Pressure Systems (NSTC 315) or equivalent
- Physical
- Refresher of all above required every 4 years

10.5.4. Propellant and Explosive Handler/ESD
- Explosive Handler's Course (NSTC 009) or equivalent
- Written test
- Type A OJT
- Physical
- Refresher of all listed required every year

10.5.5. Propellant and Explosive User
- Explosive Handler's Course (NSTC 009) or equivalent
- Explosives Safety Program Management (NSTC 010)**
- Written test and proficiency tests
- Type B OJT
- Physical
- Refresher of all listed required every 2 years

10.6 Required Course Descriptions

10.6.1. NSTC 009, Explosive Handler's Course
- Safe practices for handling, storing, shipping, and testing explosive systems, components and devices.
- 8-hour class

10.6.2. NSTC 037, Hydrogen Safety
- Guidelines for hydrogen systems design, materials selection, operations, storage, and transportation
- 2-day class

**NSTC 010 is no longer offered. Subject matter is integrated into NSTC 051.

10.6.3. NSTC 047, OSHA Record-Keeping Seminar
- Understanding new OSHA rules and requirements for record keeping
- 3-hour class

10.6.4. NSTC 051, Explosive Safety Management and Engineering
- Requirements for NASA explosive safety programs and their management
- First 3 days; same as NSTC 010, Explosive Safety Program Management.
- 5-day class (complete course)

10.6.5. NSTC 054, Safety in Hydrogen Systems Operations (refresher)
- Modified version of NSTC 037, Hydrogen Safety
- Elements of hydrogen safety necessary for technicians and operators of such systems
- 1-day class

10.6.6. NSTC 315, Safety in High-Pressure Systems
- Safety requirements and potential hazards associated with high-pressure systems and their operations
- 2-day class

10.6.7. NSTC 317, Safety in High-Pressure Operations (refresher)
- Modified version of NSTC 315, Safety in High-Pressure Systems
- Elements necessary for technicians and operators of such systems
- 1-day class

10.6.8. NSTC 0318, Compressed Gas Trailer Safety
- Safety requirements and potential hazards, common commodities, trailer configurations and components, and their operations
- 1-day class

10.7 Other Courses

10.7.1. Hazardous and Controlled Waste Generator Class

10.7.2. Introduction to Hazard Communication

EMERGENCY PHONE NUMBERS

Emergency..... 911

Medical Center..... 4-2390

Industrial Safety..... 4-0046

Chemical Spills..... 4-4357

Safety Monitor
Building 4612..... 4-2570